Appendix G

Standard Operating Procedures

(Compact Disc, Portable Document Format)

SOP-01

Environmental Sample Handling

Yerington Mine Site
Standard Operating Procedure

Revision 1
Revision Date: May 5, 2008

SOP-01
ENVIRONMENTAL SAMPLE HANDLING

TABLE OF CONTENTS

1.0 OBJECTIVE

The objective of this procedure is to establish a uniform method for the handling of environmental samples. This includes the procurement of the appropriate sample containers and preservatives, chain of custody procedures and the use of appropriate sample shipment methods.

2.0 SCOPE AND APPLICABILITY

This procedure will be used during the collection of all types of environmental media that include, but are not limited to, groundwater, surface water and soil. Handling of air samples is not addressed in the current version of this procedure.

3.0 RESPONSIBILITIES

The *Project Manager (PM),* or designee, will have the responsibility to oversee and ensure that the handling of samples is in accordance with this SOP and any site-specific or project specific planning documents.

The *field sampling personnel* will be responsible for the understanding and implementation of this SOP during all field activities, as well as, obtaining the appropriate field logbooks, forms, and records necessary to complete the field activities. Field personnel will ensure all field activities are documented completely at the end of each field day. Field personnel are responsible for assuring that the original documentation (or copies of the field log book, if needed for another project at the same site), are filed at the end of the field project, or during a long project (greater than a month) every couple of weeks.

4.0 DEFINITIONS

EnCore® Sampler – Sampler designed for collecting Volatile Organic Carbon (VOC) samples.
PPE – Personal Protective Equipment

5.0 REQUIRED MATERIALS

The materials required for this SOP include the following:

- Bound field log books
- Black waterproof and/or indelible ink pens
- Field forms
- Chain of Custody forms
- Sample Labels

6.0 METHOD

The following method outlines general considerations for sample handling in the field and maintaining sample custody after collection.

Environmental samples are collected in the field in order to evaluate whether conditions in soil gas, soil, surface water, or groundwater are hazardous. These samples therefore, should be handled with the utmost care to maintain integrity so that analytical data represents as closely as possible, field conditions. In addition, sample chain of custody is extremely important for establishing that sample integrity was maintained between field crew and laboratory.

Details regarding collection of samples are provided in other SOPs (e.g., soil sampling SOP). General considerations for handling during sampling are:

- Always wear proper PPE when handling samples.
- Sample receptacles or containers should be wrapped in a way that is protective of both surrounding containers and the container the sample is in.
- Always check and document procedures well in field logbooks or sampling forms. There is never "too much information".

Samples must be stabilized for transport from the field to the laboratory through the use of the proper sample containers and preservation techniques. This is due to the potential changes in chemical quality that may occur after samples are collected. Sample containers and preservation are discussed in the Sample Preservation SOP.

Great care must be exercised in the sampling and handling of volatile compounds (e.g. VOCs or volatile gases) in order to minimize the introduction of sampling bias. This bias is caused largely through the loss of volatile constituents. Special handling procedures are described in respective sampling SOPs for the handling of aqueous and non-aqueous samples that should be followed in order to minimize the loss of volatile constituents.

Non-aqueous samples for VOC analysis should be placed in the appropriate container as quickly as possible following their collection. Consideration should be given to trimming soil samples that have been in contact with the air and the sampling device in order to minimize the loss of VOCs and inadvertent sample contamination, respectively. Some agencies require the use of USEPA Method 5035 (or similar) that utilizes containerization in a special sampler (EnCore® or equivalent), or field methanol preservation using specially prepared containers. Lastly, the sample container should be cooled immediately after it is filled.

6.1 Sample Labels

Sample labels are required on all sample containers for the primary purpose of sample identification. Specific field data need not be recorded on the labels. The sample labels should contain the following information:

- Sample or location identification number (i.e., well number, boring number/depth, or arbitrary sample number)
- Analysis to be performed
- Preservative (even if only keeping sample chilled)
- Project name and number
- Date and time of sample collection
- Details of samplers (initials, etc.)

It is recommended that the sample label be preprinted in the office on adhesive labels prior to initiation of the sampling program. Tape should NOT be used to cover any label or seal the ends of soil sleeves. Recent studies indicate that most commercially available tapes contain VOCs and that there is the potential for contamination from the tapes.

6.2 Chain-of-Custody

The goal of implementing chain-of-custody procedures is to ensure that the sample is traceable from the time that it is collected until it, or its derived data, are used. Samples would be considered to be "in custody" under the following conditions:

- It is in personal possession.
- It is in personal view after being in personal possession.
- It was in personal possession when it was properly secured.
- It is in a designated secure area.

6.2.1 Chain-of-Custody Forms

A chain-of-custody form may be initiated at the time that the sample containers are filled or, at a minimum, when the sample containers leave the site at which they are prepared, usually that of the analytical laboratory supplying the containers. Additionally, chain-of-custody forms may be specially prepared with some initial information for the project and specific analytical methods listed prior to field work to decrease the amount of information that has to be recorded in the field. However, in this event, actual sample collection information should be recorded only in the field after the sample has been collected.

It is important that the field personnel completely fill out the applicable sections of the form. Chain of custody forms should be numerically sequenced with a number clearly indicated on the form. The chain-of-custody forms should be placed in shipping containers, protected from moisture using plastic bags (e.g., Ziploc®), and should accompany the containers during shipment to the laboratory. Chain-of-custody forms included in any shipping container should only reflect those samples that are in that container. The field personnel collecting the samples will be responsible for the custody of the samples until transport to the laboratory. Sample transfer requires the individuals relinquishing and receiving the samples to sign, date and note the time of transfer on the chain-of-custody forms. The chain-of-custody is considered to be complete after it has been received and signed in by the analytical laboratory. A copy of the chain-of-custody record should be maintained by the field personnel along with the other field records.

Common carriers (i.e., Federal Express) are not expected to sign the chain-of-custody form. However, the bill of lading or airbill becomes part of the chain-of-custody record in the event that a common carrier is used to transport the samples. Airbill or bill of lading numbers should be recorded on the chain-of-custody forms.

6.2.2 Chain-of-Custody Seals

Custody seals shall be affixed to the outside of each shipping container or cooler. Two seals are required and should be placed at two points along the front of the cooler at the point where the lid meets the body of the cooler. The seals do not necessarily need to be custody tape, but any type of tape that can be used that cannot be easily removed without showing signs of damage. The custody seals or tape shall include the date and initials of the packager.

Chain-of-custody seals or evidence tape may be used, but are not required, on the sample containers in order to demonstrate that the sample containers have not been opened or otherwise tampered with. Chain-of-custody seals or evidence tape, if used, should be affixed to each sample container as soon after sample collection as is possible.

6.3 Sample Shipment

Shipment of samples to an analytical laboratory is usually required upon completion of sample collection. Proper packaging is necessary in order to protect the sample containers, to maintain the samples at a temperature of 6°C or less, and to comply with all applicable transportation regulations.

In general, samples are shipped using packaging that is supplied by the analytical laboratory. The packaging normally includes a shippable insulated box such as an ice cooler and contains protective internal packaging materials such as foam sleeves or bubble wrap. Some laboratories use proprietary sample packaging with integral internal packaging. In either case, provisions need to be made for maintaining the temperature of the samples either with the use of ice packs or ice. Care should be taken to ensure that the sample bottles are adequately protected from breakage during shipments. Samples should be secured tightly with bubble wrap or other suitable packing media and covered with plastic bags. Ice should be added to the shipping container only after the samples have been secured with packing media. Ice should never be used to provide separation between sample bottles. Once packed, the cooler should be secured shut by wrapping fiber reinforced (strapping) tape completely around the cooler.

Custody seals shall be placed on the outside of the cooler, and clear tape should be wrapped around the cooler to cover each seal without obliterating signatures or other significant data. The shipping label shall be secured to the outside of the shipping container and, if it is attached to the top of a cooler by adhesive, clear tape shall be used to secure it to the packaging. A valid return address must appear on the shipping label in the event the shipper is unable to deliver to the designated address.

Samples will be delivered to the analytical laboratory so that there is sufficient time for analysis of the constituent with the shortest holding time. For holding times, please see SOP-02, Sample Preservation. Samples preserved at 6°C using ice packs or ice shall be shipped via overnight delivery. If samples are sent on Friday, Saturday delivery will be requested and arrangements must be made with the laboratory to receive the shipment. Chemically preserved samples may be delivered to the laboratory using ground transportation.

Regulations must be observed regarding the shipment of Dangerous Goods. Sample containers and certain field equipment may be defined as Dangerous Goods such that special requirements must be followed for their shipment. Air shipment of Dangerous Goods is regulated by the International Air Transport Association (IATA) as described in "Dangerous Goods Regulations". Shipment by ground is regulated by the U.S. Department of Transportation (DOT). Furthermore, individual shippers (e.g., Federal Express) may have additional requirements for Dangerous Goods shipment. The shipment of Dangerous Goods must be consistent with the instruction and authorization of the analytical laboratory shipping and receiving coordinator and the Health and Safety director.

Environmental samples, including groundwater samples, are currently exempt from Hazardous Goods regulations. 40 CFR 261.40(d) states, "A sample of solid waste or a sample of water, soil, or air which is collected for the sole purpose of testing to determine its characteristics or composition is not subject to this Part or Parts 262 through 267 or Part 124 of this chapter or to the notification requirements of Section 3010 of RCRA." Therefore, no special regulations are required to be followed for the shipment of environmental samples from the field. However, sample containers should be properly packed such that inadvertent spillage does not occur during shipment (e.g., any discharge spouts should be taped closed). Samples of NAPL do not fall under this exemption.

Specific regulations do exist, however, for the shipment of many reagents that are commonly used as preservatives and decontamination agents. Consequently, the shipment to the field site of "empty" sample containers containing small quantities of preservatives must be conducted in accordance with the regulations. The most significant limitations for the shipment of preservatives (IATA, 1992) involve those for nitric acid in which only small quantities (<0.5L) of low concentration (<20%) nitric acid can be shipped in any given shipment.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance for sample handling centers upon following procedures outlined above and double checks as samples are collected. Checks should be performed either by 1) the field personnel, or, preferably, 2) by a project chemist or other personnel that constantly check field chain of custody forms versus laboratory receipt acknowledgment forms, discuss condition of samples as received by laboratory personnel, and communicate constantly with the laboratory project manager to prevent quality assurance issues from starting or becoming significant problems should they occur.

8.0 REFERENCES

United States Environmental Protection Agency, 1984, Soil Sampling Quality Assurance Users Guide, EPA/600/4-84/043.

United States Environmental Protection Agency, 1986, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.

United States Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods, EPA/600/P-87/001.

United States Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/600/R-92/001.

9.0 ATTACHMENTS

None

SOP-03
Field Notes and Documentation

Yerington Mine Site
Standard Operating Procedure

Revision 0
Revision Date: June 6, 2006

SOP-03
FIELD NOTES AND DOCUMENTATION

TABLE OF CONTENTS

1.0 OBJECTIVES

The objective of this standard operating procedure (SOP) is to establish a consistent method and format for the use and control of documentation generated during daily field activities. Field notes and records are intended to provide sufficient information that can be used to recreate the field activities, as well as, the collection of environmental data. Information placed in these documents and/or records shall be factual, detailed and objective.

2.0 SCOPE AND APPLICABILITY

This procedure will be used during all field activities, regardless of the purpose by all project team personnel and subcontractors who conduct field investigations. These activities may include, but are not limited to, all types of media sampling (soil vapor, soil, groundwater, wastewater, etc), utility clearance, well installation, sample point locating and surveys, site reconnaissance, free product removal, remediation, and waste handling.

3.0 RESPONSIBILITY

The *Project Manager (PM),* or designee, will have the responsibility to oversee and ensure that field documentation is collected in accordance with this SOP and any site-specific or project specific planning documents.

The *field sampling personnel* will be responsible for the understanding and implementation of this SOP during all field activities, as well as, obtaining the appropriate field logbooks, forms and records necessary to complete the field activities. Field personnel shall ensure all field activities are documented completely at the end of each field day. Field personnel are responsible for tracking the location of all field documentation, including field logbooks. Field personnel are responsible for assuring that the original documentation (or copies of the field log book, if needed for another project at the same site), are filed at the end of the field project or during a long project (greater than month) every couple of weeks.

4.0 REQUIRED MATERIALS

The materials required for this SOP include the following:

- Bound field logbooks, and
- Black waterproof and/or indelible ink pens
- Field Forms

5.0 METHODS

This SOP primarily includes the documentation procedures for the field logbooks. However, procedures discussed in this SOP are applicable to all other types of field documentation collected, and should be universal in application. Details of other field records and forms (e.g. boring logs, sample labels, chain of custody records, and waste containment labels are discussed in the specific SOP associated with that particular field activity (e.g. borehole drilling, sample handling, investigative derived waste), and not covered in detail in this SOP.

5.1 Field Logbooks

Field personnel will keep accurate written records of their daily activities in a bound logbook that will be sufficient to recreate the project field activities without reliance on memory. This information will be recorded in chronological order. All entries will be legible, written in black waterproof or indelible ink, and contain accurate and inclusive documentation of field activities, including field data observations, deviations from project plans, problems encountered, and actions taken to solve the problem. Each page of the field logbook will be consecutively numbered, signed and dated by the field author(s). Pages should not be removed for any reason.

There should be no blank lines on a page. A single blank line or a partial blank line (such as at the end of a paragraph) should be lined to the end of the page. If only part of a page is used, the remainder of the page should have an "X" drawn across it.

In addition to documenting field activities, field logbooks will include, but are not limited to, the following:

- Date and time of activities,
- Site location
- Purpose of site visit,
- Site and weather conditions,
- Personnel present, including sampling crew, facility/site personnel and representatives (including site arrival and departure times),
- Subcontractors present,
- Regulatory agencies and their representatives (including phone numbers, site arrival and departure times),
- Level of health and safety protection,
- Sampling methodology and information,
- Sample Locations (sketches are very helpful),
- Source of sample(s), sample identifications, sample container types and preservatives used, and lot numbers for bottles and preservatives (if applicable and if not recorded on other forms or in a sample control logbook),
- A chronological description of the field observations and events,
- Specific considerations associated with sample acquisition (e.g., field parameter measurements, field screening data, HASP monitoring data, etc.) (if not recorded on another form),
- Wastes generated, containment units (including volumes, matrix, etc), and storage location (if not recorded on another form),
- Field quality assurance/quality control samples collection, preparation, and origin (if not recorded on other forms or in a sample control logbook),

- The manufacturer, model and serial number of field instruments (e.g., OVM, water quality, etc.) shall be recorded, if not using a calibration form. Also, source lot # and expiration date of standard shall be recorded if calibrated in the field.
- Well construction materials, water source(s), and other materials used on-site (if not recorded on another form).
- Sample conditions that could potentially affect the sample results,
- If deviating from plan, clearly state the reason(s) for deviation,
- Persons contacted and topics discussed,
- Documentation of exclusion zone set-up and location,
- Documentation of decontamination procedures, and
- Daily Summary.

Field situations vary widely. No general rules can specify the extent of information that must be entered in a logbook. However, records should contain sufficient information so that someone can reconstruct the field activity without relying on the collector's memory. Language used shall be objective, factual, and free of personal opinions. Hypothesis for observed phenomena may be recorded, however, they must be clearly indicated as such and only relate to the subject observation.

Logbooks will be assigned to a specific sampling team. If it is necessary to transfer the log book to alternative team member during the course of field work, the person relinquishing the log book will sign and date the log book at the time of transfer.

Field logbooks should consist of a bound book, in which the insertion or removal of pages will be visibly noticeable after the logbook has been assembled. Logbooks can be prepared by gluing or laminating pages together either at the left side or top of the page. If inclement weather is expected, logbooks may have plastic laminated front and back covers to protect the interior pages, and should not be broken apart for coping. Loose-leaf binding, such as comb binding is not considered hard binding. To maintain the integrity of the logbook, pages should be consecutively numbered prior to use. Logbook pages can be of any format, and may include blank pages for recording or field forms that are used for specific tasks. As an alternative, commercially bound and consecutive page numbered field logbooks may also be used.

5.2 Photographs

Photographs provide the most accurate demonstration of the field worker's observations. They can be significant to the field team during future inspections, informal meetings, and hearings. Photographs should be taken with a camera-lens system having a perspective similar to that afforded by the naked eye. Telephoto or wide-angle shots cannot be used in enforcement proceedings. Some industrial clients do not permit photographs on their sites. In industrial settings, confirm with the project manager that photographs are allowed.
A photograph must be documented if it is to be a valid representation of an existing situation. Therefore, for each photograph taken, several items shall be recorded in the field logbooks:

- Date and time photograph taken;
- Name of photographer;
- Site name, location, and field task;
- Brief description of the subject and the direction taken; and
- Sequential number of the photograph.

5.3 Additional Field Forms/Records

Additional field records may be required for each specific field event. The use of these records and examples are described in other SOPs specific for the activity (e.g. Borehole Logging SOP, Groundwater Sampling and Purging SOP, etc.). These other records may include:

- Borehole Logs during drilling,
- Well Construction and Development records,
- Groundwater Purge and Sample Collection Records,
- Water Level Monitoring,
- Investigation Derived Waste (IDW) Tracking Records,
- Instrument Calibration Records, and
- Health and Safety Monitoring Records and sign-off sheets.

Prior to field activities, the field sampling personnel will coordinate with the Project Manager, or designee, to determine which additional records will be required for the specific field task. These additional records will be maintained in a field file or a three-ring notebook throughout the duration of the field activities, or included in a specially prepared site-specific notebook. If the field notebook is being created, the forms may be part of the laminated book.

6.0 CORRECTIONS

If an error is made in the field, logbook corrections will be made by drawing a single line through the error, entering the correct information, and initialing and dating the change. Materials that obliterate the original information, such as correction fluids and/or mark-out tapes, are prohibited. All corrections will be initialed and dated. Some projects require that a brief reason for the change must also be added where the correction was made. Ask the Project Manager, if this requirement is necessary.

7.0 DOCUMENTATION REVIEWS

Periodically, the Project Manager, or designee, will review the field logbooks pertaining to the activities under their supervision. The elements of this review will include technical content, consistency, and compliance with the project plans and SOPs. Discrepancies and errors identified during the review should be resolved between reviewer and author of the field documentation. Corrections and/or additions of information shall be initialed and dated by the field author or reviewer.

8.0 FIELD RECORD BACKUP

Periodically, the Project Manager, or designee, will determine if and when field logbooks and records need to be photocopied. Photocopies will be maintained in the project files, and can be used as backup in the event that the original field logbook or records are lost or damaged.

9.0 DOCUMENTATION ARCHIVE

At the completion of the project, all original field logbooks and records will be store in the project files in accordance with project procedures. Typically project files lifetimes are controlled and spelled out in contractual agreements with clients. Typically, project files are archived after project finalization and kept indefinitely in archive.

10.0 REFERENCES

None cited.

11.0 ATTACHMENTS

None listed.

SOP-05
Equipment Decontamination

Yerington Mine Site
Standard Operating Procedure

Revision 1
Revision Date: September 1, 2009

SOP-05
EQUIPMENT DECONTAMINATION

TABLE OF CONTENTS

1.0 OBJECTIVES

The objective of this standard operating procedure (SOP) is to establish consistent methods to reduce or eliminate:

- Contamination and cross-contamination of environmental samples by sample equipment, other samples, or personnel.
- Health and environmental risk caused by the spread of contaminants.

2.0 APPLICABILITY

Decontamination should occur any time a sampling tool or instrument used in field investigations may contact sampled media, or personnel using the equipment. This procedure will be used in conjunction with reusable equipment, but is not required for dedicated equipment, used during field activities associated with handling, sampling or measuring environmental media such as soil, groundwater, soil gas, or air. These procedures are to be implemented primarily on-site such as at the point of use or at a designated equipment decontamination station at the project site. Equipment decontamination should be completed before each use and prior to transporting off-site.

Examples of soil and groundwater sample collection equipment usually requiring decontamination includes pumps, bailers, tubing, hand augers, split spoon samplers, and other related equipment used for the collection of samples or the measurement of field parameters.

These procedures are general minimum standards. They may be modified or supplemented for a specific project by site-specific work plans or health and safety plans.

3.0 RESPONSIBILITY

The *Project Manager*, or designee, will have the responsibility to oversee and ensure that equipment decontamination procedures are implemented in accordance with this SOP and any site-specific work plan, field sampling plan (FSP), quality assurance project plan (QAPP), and site health and safety plan (SHSP).

The *field personnel* will be responsible for the understanding and implementation of this SOP during all field activities, as well as, obtaining the appropriate field logbooks, forms and records necessary to complete the field activities.

4.0 REQUIRED MATERIALS

The equipment and supplies required for this SOP include the following:

- Clean buckets or tubs to hold wash and rinse solutions of a size appropriate to the equipment to be decontaminated.
- Tap water.
- Deionized or distilled water (grade determined by project requirements).

- Nitric acid.
- Long-handled brushes for scrubbing. Flat-bladed scrapers, garden type spray bottles (no oil lubricated parts).
- Non-phosphate detergent such as Alconox® or Liqui-Nox®.
- Plastic sheeting for the decontamination area.
- Drums to hold waste decontamination solutions and expendable supplies.
- Drum labels to properly identify the contents of the drum (more information about drum labels is included in the SOP for Investigation Derived Waste Handling Procedures)
- Plastic bags and/or aluminum foil to keep decontaminated equipment clean until the next use.
- Gloves, aprons, safety glasses, and any other PPE required in the Site Health and Safety Plan (SHSP).
- Towels and wipes.
- Dispensing bottles.
- Methanol and/or Hexane (if required by the project work plan or quality assurance plan).
- Sump and collection system for waste derived liquids.

Some Work Plans may include additional equipment rinses based on the contaminants being investigated. Examples of this are 0.1N nitric acid when cross-contamination from metals is a concern, and solvents such as methanol, isopropanol, or hexane, when cross-contamination from organics is a concern. If these are required, labeled inert dispensing bottles and Material Safety Data Sheets (MSDS) for these rinses will be necessary. Labels should be well marked. MSDS' should be filed on site and hazard communication needs to occur as outlined in the Site Safety Plan.

5.0 METHODS

Decontamination consists of physically removing contaminants from personnel or equipment. To prevent the transfer of harmful materials, procedures have been developed and are implemented before anyone enters a site and continue throughout site operations.

A decontamination plan should be based on the worst-case scenario (if information about the site is limited). The plan can be modified, if justified, by supplemental information. Initially, the decontamination plan assumes all protective clothing and equipment which leave the exclusion zone are contaminated. Based on this assumption, a system is established to wash and rinse all non-disposable equipment. Decontamination plans will be site-specific and presented in the SHSP for each site.

The decontamination area should be located, if possible, where decontamination fluids and soil wastes can be easily discarded or discharged after receipt of analytical results which determine if discharge parameters have been met. Decontamination wastewater should be managed in accordance with the Investigation Derived Waste SOP or as directed in the work plan or quality assurance plan. Wastewater will be collected and stored onsite until it can be properly disposed.

5.1 Decontamination Station Set-up

Large equipment. A decontamination pad should be established for cleaning of heavy equipment or large sampling tools. This pad can be a prefabricated area that already exists on site for washing large equipment, or can be constructed. If a prefabricated area exists, it needs have characteristics that allow for collecting fluids and solids that will fall off the large equipment. Decontamination pads can be constructed in a variety of ways, but things to consider during construction are the following:

- The pad will need to be constructed so it provides complete secondary containment. Hence all sides will require berms to prevent off pad migration of fluids. The berms need to be constructed by considering the balance between sump pump removal rates and the amount of fluid that will be generated.
- Fluids from decontamination processes cannot escape and be directly discharged vertically into the ground; hence if plastic sheeting is used it should be minimally double layered and thick (greater than 8 mil).
- The pad will have to drain in one general direction where a sump pump can collect fluids.
- The pad will need to be located near power and water, if possible. However, a generator can supply power and water can be trucked in.

Small equipment. For small equipment decontamination and PPE decontamination, a smaller station is established, either in the contaminant reduction zone or at the sampling location or well if contamination zones are not established. For this station, clean buckets or tubs (5 gallon buckets are most common) should be used. Buckets should be placed on plastic sheeting to prevent spillage to the ground, and to help keep the decontamination area and equipment as clean as possible. The buckets should be filled half to three-quarters full as follows:

Step 1 Tap water with non-phosphate detergent such as Liqui-Nox made up as directed by the manufacturer.

Step 2 Tap water for rinsing.

Step 3 If practicable use a 2% nitric acid solution mixed with deionized or distilled water for the second rinsing. Some equipment can be damaged by nitric acid (i.e. Geosquirt pump, water level meters), check equipment Operating Manual before using a nitric acid solution.

Step 4 Deionized or distilled water for the final rinsing

A clean area, generally covered with plastic sheeting or large clean plastic bags, is also needed to set down decontaminated equipment prior to reuse or air drying and packaging for later use. A stainless steel rack (e.g., grill for barbecue) can often help drying activities.

5.2 Procedure

After the decontamination area is set up, equipment decontamination is comprised of four general steps:

1) Removal of gross (visible) contamination
2) Removal of residual contamination
3) Prevention of recontamination, and
4) Disposal of wastes associated with the decontamination

5.2.1 Remove Gross Contamination

Gross contamination generally applies to soil sampling equipment, which may have significant residue clinging to the piece of equipment. This can be removed by dry brushing or scraping or by a high-pressure steam or water rinse often, in areas not grossly contaminated, steam washes may be all that is applied to larger equipment, such as drill casings. If utilizing high-pressure steam or water, the rinse water should be containerized as investigation derived waste. Since a significant amount of wastes may be generated, this operation is often best conducted on a decon pad, which has been designed as a secondary containment area to collect wastes.

5.2.2 Remove Residual Contamination

All sampling equipment used at the site must be cleaned prior to any sampling effort, after each sample is collected, and after the sampling effort is accomplished.

Removal of residual contamination consists of the following steps:

1) Place the item in the first bucket (detergent wash) and scrub the entire surface area of each piece of equipment to be decontaminated. Utilize scrub brushes to remove all visible contamination. Change the water periodically to minimize the amount of residue carried over into the second rinse.

2) Place the item in the second bucket (clear water rinse – tap or deionized water) and rinse. Change the water periodically to minimize the amount of residue carried over into the third rinse.

3) Rinse the item with a weak nitric acid solution, either in a bucket or with a squeeze bottle. The purpose of the nitric acid wash is to remove any remaining metals that may contaminate the equipment. The acid solution is very weak but use extra caution to minimize contact with the solutions, including heavier gloves and goggles. Change water as necessary.

4) Place the item in the fourth bucket (deionized or distilled water) and repeat the rinsing procedure. Change water as necessary.

5) Unless the Work Plan directs additional rinses, place the item on a clean surface such as plastic sheeting to await reuse or packaging for storage (e.g., wrapping foil).

Additional rinses for field sampling equipment are sometimes called for in the Work Plan. This may include a pesticide-grade solvents (e.g., methanol, isopropanal, or hexane) when organic contamination may be present. These rinses are applied with a wash bottle so that the stream of liquid has completely covered the area of surface of the equipment that may come in contact with the sample. The rinse should be conducted over a container to catch the runoff from the equipment.

Solvent rinses should be conducted from more polar (i.e., methanol) to less polar (i.e. hexane or methylene chloride), and allowed to air dry if at all possible. Application of the methanol and hexane rinses requires liberal amounts of hexane to remove the methanol. Under some circumstances (e.g., poor weather), complete air drying of equipment is impractical. In such a case, allowing the equipment to dry as long as practical followed by an organic free water rinse can be used.

5.2.3 Contamination Removal for Non-Dedicated Bladder Pump and Tubing

Removal of contamination for a non-dedicated bladder pump with non-dedicated tubing consists of the following steps:

1 Set-up plastic sheeting for your decontamination area. Disassemble the cover and head from the body of the pump to remove the bladder. A new bladder will be installed after pump and tubing is decontaminated.

2 Place the cover and head unit, with the tubing still attached, into the first 5-gallon bucket (detergent wash). Attach approximately 2 feet of silicon tubing to the end of the air line tube on the pump. Connect the silicon tubing to a peristaltic pump.

3 With the cover and head unit in the detergent wash, turn on peristaltic pump and pump out three times the volume of the tubing. For example, if the tubing is 50 feet in length, pump out 2 liters of the detergent wash through the tubing. See formula below to calculate the amount of solution to purge through tubing. Containerize all solutions used in the decontamination process. Change water periodically to minimize the amount of residue carried over into the next rinse.

The tubing volume may be calculated using the formula $V = CF*d^2h$, where

V = volume of water (gallons)
d = diameter of well (inches)
h = height of water column (feet)
CF = conversion factor (0.0408) that includes conversion of cubic feet to gallons, inches to feet, and diameter to radius.

Once the volume in gallons is known, it can easily be converted to liters using the following conversion factor: 1 US gallon = 3.78541178 liter

4 Repeat this step with tap water followed by a weak nitric acid solution and finally with deionized or distilled water.

5 Use a scrub brush to wash the body of the pump, and a clean rag to wipe the outside of the tubing, through all four decontamination solutions.

6 Apply a new bladder to the pump head and re-assemble pump. Place clean pump and tubing in plastic bag to avoid recontamination.

5.2.4 Contamination Removal for Non-Dedicated Bladder Pump and Dedicated Tubing

Removal of contamination for a non-dedicated bladder pump with dedicated tubing consists of the following steps:

1 Set-up plastic sheeting for your decontamination area. Disassemble the cover and head from the body of the pump to remove the bladder. Disconnect tubing from pump. A new bladder will be installed after pump is decontaminated.

2 Place the disassembled, non-dedicated pump (with bladder removed) into the first 5-gallon bucket (detergent wash). Use a scrub brush to wash the body of the pump

3 Repeat this step with tap water followed by a weak nitric acid solution and finally with deionized or distilled water.

4 Change water periodically to minimize the amount of residue carried over into the next rinse.

5 Apply a new bladder to the pump head and re-assemble the pump. Place clean pump in clean plastic bag and dedicated tubing in dedicated plastic bag to avoid recontamination.

5.2.5 Prevent Recontamination After Decontamination

After the decontamination process, equipment should be stored to preserve its clean state to the extent practical. The method will vary by the nature of the equipment. Protection measures include covering or wrapping in plastic or sealable plastic bags, or wrapping with oil-free aluminum foil.

5.2.6 Disposal of Contaminants and Spent Rinse Fluids

All washing and rinsing solutions are considered investigation derived waste and should be containerized. After use, gloves and other disposable PPE should also be containerized and handled as investigation derived waste. See SOP on Investigation Derived Waste Handling Procedures.

5.3 Record Keeping

The decontamination method should be documented within the field documentation designated for the project. Entries documenting the procedure used, fluids used, lot numbers for fluids, and any changes and approval for changes should be entered into a bound field notebook or on project-specific forms. Upon completion of the field activity, it is the responsibility of the field personnel to ensure the project/task manager receives copies of all of the field documentation.

6.0 REFERENCES

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. October 1985.

United States Environmental Protection Agency (U.S. EPA), 1990. Procedures to Schedule and Complete Sampling Activities in Cooperation with EPA Region VII Environmental Services Division. February.

U.S. EPA Region VII, 1991. Environmental Services Division Operations and Quality Assurance Manual. February.

U.S. EPA, 1987. A Compendium of Superfund Field Operations Methods, Volumes I and II. EPA/540/P-87/001a&b.

U.S. EPA, 1992. Standard Operating Safety Guidelines; Publication 9285.1-03. June.

The Code of Federal Regulations, 1993. Title 29, 1910.120. July.

7.0 ATTACHMENTS

None.

7SOP-07

Groundwater Monitoring Well Installation and Development

Yerington Mine Site
Standard Operating Procedure

Revision 0
Revision Date: June 6, 2006

SOP-07
GROUNDWATER MONITORING WELL INSTALLATION

TABLE OF CONTENTS

1.0 OBJECTIVES

The objective of this standard operating procedure (SOP) is to provide the methods to be used for the installation and development of groundwater monitoring wells and to provide standardized reporting formats for documentation of data. This SOP has been specifically designed with the objective of installing and developing wells for environmental investigations.

2.0 SCOPE AND APPLICABILITY

This procedure is intended for use for the installation, development, and documentation of monitoring wells that will be used for environmental investigations.

Specific monitoring well design and installation procedures depend on project-specific objectives and subsurface conditions and should be discussed in project-specific planning documents. The following aspects will need to be determined when planning a well installation:

- Borehole drilling method
- Construction materials
- Well depth
- Screen length
- Well construction materials
- Location, thickness, and composition of annular seals
- Well completion and protection requirements.

Groundwater monitoring well installation and development will be performed in accordance with applicable well standards for the area of the investigation, this SOP and the project-specific planning documents. Drilling methods employed to pilot the borehole for monitoring well installation will be dependent on the physical nature of the subsurface materials (unconsolidated materials and/or consolidated materials) at the site. The drilling contractor shall be a licensed water well driller, in accordance with local and state requirements, and a qualified drilling contractor for the installation of groundwater monitoring wells for environmental investigations.

2.1 Health and Safety

Potential physical and chemical hazards will need to be addressed when planning monitoring well installation. A health and safety plan that addresses known and anticipated field conditions must be prepared prior to field work and be followed during well installation.

3.0 RESPONSIBILITES

The *Project Manager* is responsible for ensuring that the project involving monitoring well installation is properly planned and executed and that the safety of personnel from chemical and physical hazards associated with drilling and well installation is provided for.

The *Field Geologist or Engineer* is responsible for directly overseeing the construction and installation of the monitoring wells by the driller and to ensure that the project specific well-installation specifications defined in the project-specific planning documents are followed and that pertinent data are recorded on appropriate forms and in the field notebook. Monitoring well construction and boring completion will be conducted under the supervision of an appropriately qualified and registered person as defined by local regulations.

The *Site Safety Officer (SSO)*, typically the field geologist or engineer, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field. If a subcontracted firm conducts installation and documentation activities, then the firm will designate a site safety officer.

4.0 REQUIRED MATERIALS

Many materials are required for successfully completing the installation and development of monitoring wells. The drilling Subcontractor often supplies much of the material. However, the field personnel should be aware of what is required to conduct the work so they have their own supplies and can provide complete Subcontractor oversight. The following is a general list of materials that are needed for performing the tasks outlined in this SOP.

Geologist

- Hand lens
- Health and Safety supplies (e.g., steel toed boots, gloves, hard hat, etc.)
- Lithologic Logs and Well completion forms
- Logbook
- Logging assistance tools (e.g., grain size charts, color charts)
- Measuring tapes (both long weighted cloth type and small measuring tape, preferably marked in tenths and hundredths of a foot)

Drilling Subcontractor

- Drilling equipment (depends upon the type of drilling, e.g., drill stem, auger, generators, compressors, steam cleaners, etc.)
- Well drilling supplies (drilling mud)
- Decontamination Pad construction supplies
- Well construction supplies (screen, well casing, sand pack, bentonite chips, bentonite, cement mixture, water).
- Health and safety records required for working on site
- Ancillary support vehicles

5.0 METHODS

The borehole diameter must be a minimum of four (4) inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs and grout seals. All boreholes will be cleared for shallow obstructions by following the SOP for Utility Clearance.

5.1 Drilling Methods

Several drilling methods are available for use in creating a borehole for well installation. These methods include hollow stem, air rotary, mud rotary, and cable tool, among others. The drilling method selected will be based on the physical properties of the subsurface materials.

5.1.1 Hollow Stem Auger Methods

Hollow stem auger uses continuous flight hollow stem auger with a bit on the bottom to drill and maintain an open borehole. The continuous flight auger drives the drill cuttings to the surface as drilling progresses. The walls of the auger minimize the amount of unconsolidated materials entering into the space inside the casing. Intact soil samples are collected by pounding a sampler ahead of the auger. The well casing, filter pack and seal are installed inside the auger. The auger is removed slightly ahead of backfilling as filter pack and grout are added. Careful recording of the amount of each material used should be recorded in the field logbook.

5.1.2 Mud Rotary Methods

Mud rotary drilling uses drilling fluids to circulate drill cuttings to the surface. Drilling fluid will consist of only uncontaminated air, water or uncontaminated water mixed with bentonite. Powdered bentonite or an approved equivalent will be used as an additive in the drilling fluid. Bentonite will be mixed into the drilling fluid using a mud mixer and a portable mud tank. Drilling fluid density and viscosity will be maintained at appropriate levels for the various lithology encountered and in accordance with material specifications.

A shale-shaker and de-sanding system will be used to maintain the density and viscosity of the drilling fluid. Sand content will be minimized to the degree possible by maintaining no greater than 4 percent sand by mud volume.

If water or other drilling fluids have been introduced into the borehole during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water introduced by flushing the borehole before well installation and/or by pumping the well during development.

5.1.3 Air Drilling Methods

The following are descriptions of air rotary, "down-the-hole", and dual-wall reverse circulation air rotary methods. Air rotary uses air as a primary means of transporting drill cuttings to the surface. A large compressor provides filtered air that is piped to the swivel hose connected to the top of the Kelly bushing or drill pipe. The air, forced down the drill pipe, escapes through small ports at the bottom of the drill bit, thereby lifting the cuttings and cooling the bit. The cuttings are blown out the top of the hole and are collected at the surface in a cyclone unit and a two- to four-yard roll-off container. Injection of a small volume of clean water into the air system controls dust and lowers the temperature of the air so that the swivel is cooled. Air drilling is effective in semi-consolidated or consolidated materials.

A second direct rotary method using air is called the "down-the-hole" or percussion down hole hammer drilling system. A pneumatic drill operated at the end of the drill pipe rapidly strikes the rock while the drill pipe is slowly rotated. The percussive effect is similar to the blows delivered by a cable tool bit. Cuttings are removed continuously by the air used to drive the hammer.

A third direct air rotary method is called the Air Rotary Casing Hammer (ARCH) method is used where an outer steel casing is advanced slightly behind the drill bit. The drill bit reams material in front of the casing and then the casing is advanced with a pneumatic hammer down the hole to prevent hole collapse. Cuttings are collected in a tube system that conveys them into a cyclone at the surface.

Dual-wall reverse circulation air rotary method uses flush-jointed, double wall pipe in which the air moves by reverse circulation. The airflow is contained between the two walls of the dual-wall pipe and only contacts the walls of the borehole near the bit. Dual-wall pipe can be driven into place in loosely consolidated materials by a pile hammer as a drive bit is cutting the formation. Downhole air hammers and tricone bits can also be used to cut the formation. The air lifts the cuttings to the surface through the inner pipe. Dual-wall methods can be applied in consolidated and unconsolidated formations.

5.1.4 Rotosonic Drilling

Rotosonic is a core drilling method that employs simultaneous high frequency vibration and low speed rotational motion along with downward pressure to advance the core barrel without use of drilling fluid or air. The core barrel can generally advance from five to twenty feet at one time, depending on the length of the core barrel. The drill cuttings are brought to the surface by removal of the entire core barrel from the borehole and the cuttings are vibrated out of the barrel. If required for logging purposes, the cuttings are collected in plastic sleeves. An outer casing is generally washed-down with water to stabilize the borehole from collapse and heaving sand. The outer casing prevents cross-contamination and formation mixing. The advantage of rotosonic core drilling is that no drilling fluids or muds are required to bring the cuttings to the surface and the aquifer is less likely to be contaminated by the drilling method.

5.2 Borehole logging

Boreholes will be logged using cuttings and samples collected during drilling activities. Soil or rock samples will be collected as described in the SOP for Soil Sampling. Cuttings and soil and rock samples will be described at the frequency presented in the project-specific planning documents following the procedures outlined in SOP for Field Classification and Description of Soil and Rock.

After drilling has been completed, the field geologist/engineer will measure the total open depth of the borehole with a weighted, calibrated tape measure and document the depth. The field geologist will then collaborate with the supervising geologist by reviewing lithologic units encountered, water levels, if any, and other logged information to determine the well construction details.

Boreholes/well locations should be clearly designated in the field notes using notes and a hand sketched layout and should include the following information:

- Measurements of each boring/sample point relative to fixed objects (building, structures, etc),
- Boring/sample location with their identification number noted,
- North arrow or other compass directional indicator, and
- Other essential site features and/or investigation features (underground storage tanks, piping, above ground tanks, etc.).

5.3 MONITORING WELL CONSTRUCTION PROCEDURES

Monitoring wells will be constructed in accordance with state and local agency requirements, and will include at a minimum the following materials:

- Borehole backfill for overdrilled boreholes prior to well installation,
- Well casing and screen
- Filter pack materials
- Well sealing materials (e.g., bentonite pellets, cement, powdered bentonite), and
- Surface seals and materials for well surface completion (e.g., concrete, protective steel casing, steel posts, surface boxes).

A discussion of these materials and how they are used is provided in more detail in the following sections.

5.3.1 Backfilling.

If backfilling the borehole to the appropriate well installation depth is necessary, neat cement, bentonite grout, bentonite pellets or filter pack sand may be used. The backfill material selected for use will depend on site conditions, lithology, and project-specific requirements. Most often the borehole requires complete sealing with lower layers, so neat cement, bentonite grout, or bentonite pellets are used. The setup time should be a minimum of 48 hours for neat cement and 24 hours for bentonite grout and bentonite pellets prior to beginning well construction. Field personnel should remeasure and verify that the bottom of the bore hole is exactly where it should be set before proceeding with well construction. The necessary setup times may be reduced if manufacturer- approved additives are mixed with the grout to accelerate the cure time.

If neat cement or bentonite grout is used, a tremie pipe will be required to place the grout in the bottom of the hole. Grouting the borehole may be difficult to accomplish, if the portion of the borehole to be grouted is significantly lower than the groundwater level. Provisions will be necessary to support the screen and riser pipe to prevent them from sinking into the grout. Care will be taken to frequently measure the total borehole depth when adding grout to the bottom of the hole. Grout should have thickened to a hardened state before proceeding. The thickness of the grout will be calculated based on depth readings and recorded. If a well has been backfilled too much it may require reaming to clear out the overfilled material.

Depending upon the lithology some distance should be planned between the fill in a borehole and the bottom of the screened interval. Unless this distance would result in a breach confining layer, or the well screen requires setting directly on the impermeable zone due to site requirements, the bottom of the well screen should be set at a maximum of 6 inches above the top of any backfill. The distance between the top of fill and the bottom of the well screen should be filled with a fine sand buffer.

Bentonite pellets should be carefully dropped into the borehole to minimize the risk of pellets sticking to the side of the borehole when dropped through a water column. Pellets are generally easier to place than bentonite chips because pellets do not hydrate as quickly, hence pellets are the preferred method for small backfill jobs where significant confining zones have not been breached.

5.3.2 Well Casing and Screen

The monitoring well will consist of factory-sealed commercially available well screen and casing. Well screens and casing will typically be constructed of polyvinyl chloride (PVC), a type of plastic, but may also be constructed of stainless steel or Teflon depending on subsurface conditions or other project requirements. Stainless steel casing shall meet one of the following standards: American Society For Testing Materials (ASTM) A-53-93A or B, A-589-93, or American Petroleum Institute 5L, March 1982 Edition to conform to the minimum standards given in Table A of that document.

Plastic casing and liners shall meet the requirements of ASTM Standard F480-94 and the National Sanitation Foundation (NSF) International Standard Number 14-1990, Plastic Piping System Components and Related Materials. Evidence of compliance shall be included in the current NSF listing and display of the NSF seal on each section of casing, and marking the casing in accordance with the requirements of ASTM Standard F-480-94. Plastic well casing and liners must be Standard Dimension Ratio (SDR)-rated and conform to the minimum requirements given in Table B of the above-referenced document.

Well screens shall be constructed of non-corrosive and non-reactive material. Well screens shall be permanently joined to the well casing and shall be centered in the borehole. The anticipated length of screen and the reasoning behind choosing the length of screen will be determined when developing the project-specific planning documents. Modification can be made in the field, but will be done in consultation with the PM, or their designee such as the Project Technical Manager or Responsible Geologist.

Screen slot type and size will be dependent on the sand pack material and the aquifer formation material. Casing will be connected by flush-threaded or coupled joints and will be completed with a bottom cap. A collection sump may be installed below the screen and will vary in length depending on lithology and project needs. The collection sump and bottom cap will be connected to the well screen by flush threaded or coupled joints. Plastic casing must have threaded joints and O-ring seals. Solvent, glue, or anti-seize compounds will not be used on the joints. With deep wells (greater than approximately 100 feet below grade), centralizers should be used to keep the well casing plume and straight in the borehole. Centralizers should be placed at approximately 20 foot intervals in the screen interval and 40 foot intervals throughout the blank casing interval.

For water table wells, well screens should be placed such that some of the screened interval is above the water table, and some section is below the water table. This allows for seasonal fluctations. The amount of split should be determined by the lead responsible geologist and be based upon local conditions.

Casing and screen (well string) must be clean, free of rust, grease, oil or contaminants and be composed of materials that will not affect the quality of the water sample. All casing shall be watertight. The casing shall be centered in the borehole, be free of any obstructions and allow sampling devices to be lowered into the well. The well string shall be hung in the borehole during installation so that the well is sufficiently plumbed and straight after completion.

5.3.3 Filter Pack

Monitoring wells installed in unconsolidated material will be constructed with filter packs. When used, the filter pack will be the only material in contact with the well screen. The filter pack will consist of sand or gravel. The sand or gravel used for filter pack material shall be sized to match the screen slot size and the surrounding lithology to prevent subsurface materials from penetrating through the sand or filter pack, and preventing the sand or filter pack from entering the well. Sizing of the filter pack material is often conducted using sieve analysis and following interpretative procedures outlined in Driscoll (1986). The sand or gravel shall be free of clay, dust, and organic material. Crushed limestone, dolomite, or any material containing clay or any other material that will adversely affect the performance of the monitoring well shall not be used as filter pack. The filter pack will extend a maximum of six (6) inches below the bottom of the screen to two (2) to three (3) feet above the top of screen. The filter pack material may be placed in the well by pouring the sand into the open borehole, or tremied into place depending upon site-specific criteria. However, in all cases, filter pack material should be added carefully with continuous measurements by the field geologist to prevent bridging of the filter pack material.

Groundwater wells completed into competent bedrock material are often not completed with filter pack material, and can be completed as an open hole over the screened interval. Completion in this manner should be carefully considered and approved by regulatory agencies prior to field mobilization.

The well will be gently bailed and surged with a bailer and surge block after the filter pack has been added to the borehole and before the seal is placed in the annular space. A surge block consists of a rubber or leather and metal plunger attached to a rod or pipe of sufficient length to reach the bottom of the screen. Surging should be maintained for at least five minutes and the entire length of saturated screen will be surged to help settle the filter pack. The top of the filter pack will need to be gauged after surging and additional filter pack material may need to be added if settling has occurred.

Sometimes project specific requirements may identify that a transition sand be emplaced above the main filter pack. This transition sand is usually much smaller grain size than the filter pack, and is emplaced to provide added protection that grout invasion into the filter pack will not occur when deep wells (greater than 200 feet deep) are installed. Transition sands can be emplaced up to 10 or 20 feet above the regular sand pack interval. An alternative to transition sands is to use additional well seal material such as bentonite pellets.

5.3.4 Well Sealing Material

The wells will have an annular space seal that extends from the top of the filter pack to the surface. The annular sealing material above the filter pack will prevent the migration of fluids from the surface and between aquifers. Sealing material will be chemically compatible with anticipated contaminants. Hydrated bentonite chips or pellets are typically used as an annular seal directly above the filter pack. The annular seal should be a minimum of 3 feet thick unless site-specific requirements dictate otherwise. For example, as mentioned above, deep wells may require additional sealant material (10 to 20 feet thick versus 3 feet) between the sand pack and cement ground annular fill above to prevent grout invasion into the filter pack interval. Cement and/or bentonite grout are typically used as annular fill above the seal. Above the sealant material a bentonite grout mixture is often used as an annular fill to complete the well installation to within 2 feet of the surface. Grouting emplacement will occur using a tremie pipe so that the grout fills the annular space from the bottom to the surface without allowing air pockets to form in the filled zone.

5.3.5 Surface Completions

Above Grade or Monument Surface Well Head Completion

With above-grade well completions, the well casing will extend to 1 to 2 feet above the ground surface. A locking cap will be placed at the top of the casing and the cap will be watertight. The section of casing that sticks up above ground will be protected by a steel protective pipe, set at least 2-feet deep into a concrete surface seal. A concrete pad should be constructed around the protective steel pipe. The pad should be square, approximately 1.5-by-1.5 to 2-by 2-feet, sloped slightly away from the well, and the top of the pad should be approximately 4-inches off the ground. Specific client needs may differ from this construction, and such requirements should be outlined in project specific planning documents. The top of the protective pipe will have a vented lockable cap. Protective steel posts will be installed in areas where the well could be struck by vehicles or heavy equipment. In addition, a "weep" hole should be drilled in the bottom of the protective steel pipe. In areas where freezing may occur, placement of the weep hole is critical; little volume should exist in the protective casing above the weep hole where water could accumulate and freeze thereby damaging the well. A "V" notch or other permanent mark will be placed at the north edge of the top of the well casing that will be used as the reference point for well elevation surveying and water level monitoring.

Ground or Grade Surface Well Head Completion

Monitoring well casing may terminate at the ground surface with a flush mounted traffic-rated road box. Road box installations must use a watertight well cap for the well riser pipe in addition to a watertight road box to prevent surface water from entering the well. The well casing should extend approximately 3 inches above the sealant in the bottom of the well box. The traffic-rated road box and surface concrete completion should meet Class A specifications, which meet a minimum 4000-pound compressive strength. The surface completion should provide positive drainage away from the well box to prevent ponding around the well. In traffic areas and sidewalks, this positive drainage slope away from the box should be minimized to prevent physical hazards. The surface seal around the box should be a minimum of 12 inches around the perimeter of the box. As discussed above a reference mark should be placed on the top of the well casing for well elevation surveying and water level monitoring.

5.3.6 Monitoring Well Location and Surveying

Monitoring wells will be located by parcel coordinates required by local permit requirements. Each well will be surveyed by a licensed surveyor in the state where the well has been installed and tied to an established state or county benchmark, site conditions permitting. The vertical survey will be accurate to 0.01 foot relative to mean sea level. Both the top of casing and ground surface elevation near the well will be surveyed for vertical control. The “V” notch cut on the north side of each well casing will be used as the surveyor’s reference mark. For horizontal control, each well will be tied to an existing site coordinate system and will be surveyed to a horizontal accuracy of 0.1 foot.

5.4 Well Development

Monitoring well development is necessary to ensure that complete hydraulic connection is made and maintained between the well and the aquifer material surrounding the well screen and filter pack. The appropriate development method will be selected for each project on the basis of the circumstances, objectives, and requirements of that project.

The appropriate development method will be selected for each project based on the lithology, objectives, and requirements of that project. Project-specific planning documents will identify the specific development method to be used. In general, most wells will be developed by using surge block and bailing methods to draw the coarse and/or fine material out of the sand pack. Other development methods that may be used include jetting, airlift, and submersible pump methods. These methods are discussed further below. Jetting is typically not used as a development method for environmental investigations, but is commonly used for water resource monitoring wells or production wells.

Well development should begin no sooner than 48 hours after well installation. However, if drilling muds are used during well installation, well development should occur approximately 24 hours following well installation so that the drilling mud does not set up in the well screen section.

Generally a phased process is used to develop wells, starting with a gentle bailing phase to remove sand, followed by a surging phase, then a pumping phase after the well begins to clear up. The following paragraphs provide more detailed information.

After a well is first installed, and in fact, often before the bentonite pellet seal is set, gentle bailing is used to remove water and sand from the well. The purpose of this technique is used to settle the sand pack. After further well sealant materials have been added and allowed to set for approximately 48 hours, bailing is resumed as part of well development. The purpose of bailing is to remove an fine material that may have accumulated in the well, and start pulling in natural material into the sand pack. Bailing is often conducted until the sand content in the removed water begins to decrease.

After the sand content begins to decrease, surging is conducted. A surge block is used to move sediments from the filter pack into the well casing. A surge block consists of a rubber (or leather) and metal plunger attached to a rod or pipe of sufficient length to reach the bottom of the well. All surge blocks will be constructed of materials that will not introduce contamination into the well. Surge blocks should have some manner of allowing pressure release to prevent casing collapse. The surge block is moved up and down the well screen interval and then removed, followed by a return to bailing to remove any sand brought into the well by the surging action. Care should be taken to not surge too strongly with subsequent casing deformation or collapse; the well screen interval is often the weakest part of a well. Surging should be followed by additional bailing to remove fine materials that may have entered the well during the surging effort.

After surging has been completed and the sand content of the bailed water has decreased, a submersible pump is used to continue well development. The pump should be moved up and down the well screen interval until the obtained water is relatively clear. Well development will continue until the water in the well clarifies and monitoring parameters such as pH, specific conductivity, and temperature stabilize as defined in the project-specific planning documents. It should be noted that where very fine-grained formations are opposite the screened interval, continued well development until clear water is obtained might be impossible. Decisions regarding when to cease development where silty conditions exist should be made between the field supervisor and PM.

During well development pH, specific conductivity, temperature, and turbidity should be monitored frequently to establish natural conditions and evaluate whether the well has been completely developed. The main criteria for well development is clear water (Nephelometric turbidity units or NTU of less than 5). As mentioned above, clear water can often be impossible to obtain with environmental monitoring wells. A further criteria for completed well development is that the other water quality parameters mentioned above stabilize to within 10 percent between readings over one well volume.

The minimum volume of water purged from the well during development will be approximately a minimum of 3 borehole volumes (wells will typically not reach stabilization of water quality parameters before this condition is achieved and may not have reached stability even after this threshold has been achieved). The above is a general guideline for difficult well development - project-specific planning documents should address project constraints on well development. Development water will be stored in 55-gallon Department of Transportation (DOT) -approved drums and/or baker tanks depending upon the total volume of purge water removed from the newly installed wells.

5.5 Disposal And Decontamination

All drill cuttings and fluids generated during well installation and development will be containerized pending analytical results and determination of disposal options as outlined in the Investigation-Derived Waste Handling SOP unless project-specific requirements unless specify otherwise. Waste containment and disposal will occur in a manner that will not result in contamination of the immediate area or result in a hazard to individuals who may come in contact with these materials.

All drilling and well construction equipment that comes into contact with the borehole will be decontaminated by following the Equipment Decontamination SOP.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Borehole drilling and well construction details will be documented in detail in the field. Field documentation forms will consist of a lithologic borehole log, a well construction log, and daily field note forms. Examples of these forms are included in Attachment A. Deviations from project-specific planning documents will be documented and explained in daily field notes. The program manager will be contacted to discuss project deviations.

Field quality control can be maintained through 1) making sure employees are properly trained to conduct the work being implemented, and 2) performing routine field audits to evaluate how well employees are following procedures. These two aspects of QA/QC are detailed in the Quality Assurance Program documentation.

7.0 RECORDS

Field notes and logs will be submitted to the Project Manager or designate immediately following the field event for checking and revision purposes. The Project Manager or designate shall review and transmit the completed forms for incorporation into the project file.

8.0 REFERENCES

California Department of Water Resources, 1981, State of California Water Well Standards, Bulletin 74-81.

California Department of Water Resources, 1990, State of California Water Well Standards (modified), Bulletin 74-90.

Driscoll, F.G., 1986, Groundwater and Wells, Second Edition, Johnson Filtration Systems, Inc., St. Paul, MN.

United States Environmental Protection Agency, 1989, Handbook for Suggested Practices for the Design and Installation of Monitoring Wells, EPA 600/4-89/034, Reprinted by the National Ground Water Association.

9.0 ATTACHMENTS

None

SOP-09
Groundwater Sample Collection

Yerington Mine Site
Standard Operating Procedure

Revision 2
Revision Date: January 22, 2009

SOP-09
GROUNDWATER SAMPLE COLLECTION

TABLE OF CONTENTS

1.0 OBJECTIVES

The primary objective of this standard operating procedure (SOP) is to establish a uniform method for the collection of representative groundwater samples from monitoring wells, and to reduce the potential variability associated with purging and sampling.

2.0 SCOPE AND APPLICABILITY

This SOP will be used to support groundwater monitoring programs and conducting the field groundwater sampling activities. Groundwater sampling involves two primary operations, purging stagnant water from a well followed by the collection of a sample from the same well. Groundwater sampling variables can be significantly controlled through the appropriate selection and use of purging and sampling equipment, and through the use of procedures that are described in this SOP.

3.0 REQUIRED MATERIALS

Materials required for conducting groundwater sampling are variable depending upon the method chosen to conduct the sampling. Therefore the listing of materials will be separated into two parts in this SOP. This section will present materials that are general in applicability – things that should be included regardless of purge or sampling method. In Section 5, where specific methods and approaches are discussed, additional materials will be listed. General materials that should be considered regardless of method are as follows:

- Personal protection equipment (as required by the Site Health and Safety Plan)
- Health and safety monitoring equipment (e.g., PID)
- Well Completion Forms and Data from previous sampling efforts (if available)
- Water level indicator
- Decontamination supplies (5 gallon buckets, decontamination fluids, squirt bottles)
- Water quality monitoring equipment
- Purge pumps and control boxes
- Purge water collection containers
- Generator
- Compressed nitrogen and/or carbon dioxide bottles
- Permanent marking pens
- Notebook
- Calculator
- Measuring tape

- Garbage bags
- Shipping labels and Chain of Custody records
- Shipping coolers and ice
- Filters (0.45 µm), if appropriate
- Tubing

4.0 RESPONSIBILITIES

The *Project Manager*, or designee, will have the responsibility to oversee and ensure that groundwater purging and sampling procedures are implemented in accordance this SOP and any project- or site-specific planning documents.

The *field personnel* will be responsible for the understanding and implementation of this SOP during groundwater sampling activities, as well as, obtaining the appropriate field logbooks, forms and records necessary to complete the field activities.

5.0 METHODS

5.1 General Considerations

Groundwater sampling involves two primary operations. These include the purging of stagnant water from the well followed by the collection of a sample. Groundwater sampling variables can be significantly controlled through the appropriate selection and use of purging and sampling equipment, and through the use of procedures that are described below.

Good communication is essential to the ultimate success of a groundwater sampling project. This includes communication within the project team, as well as communication with the client and analytical laboratory, when establishing project objectives.

Good communication with the project team, laboratory, client, and, if appropriate, regulatory agencies, includes complete project specific planning documents such as field sampling plans, quality assurance plans, and scope of work documents for subcontracted laboratories. Plans should include detailed information with respect to site-specific requirements, with reference to SOPs wherever possible, and risk criteria that will be used to assess the data. The quality assurance plan and laboratory scope of work (of which the quality assurance plan can be part) should contain detailed information regarding what is expected from the laboratory regarding the methods to be used, quality assurance measures and calibrating corrective measures, and deliverables (especially electronic deliverable formats). A detailed quality assurance plan is even more important in light of EPA's Performances Based Measurement Standard (PBMS) initiative.

In addition to good communication, the project plans should consider equipment decontamination, sampling equipment, sampling sequence, and field quality assurance/quality control (QA/QC) samples. These are described in the following sections.

5.1.1 Dedicated and Disposable Equipment

Use of dedicated and new, disposable purging and sampling equipment are preferable to decontamination of reusable sampling equipment. Dedicated equipment, and use of new, disposable equipment, can virtually eliminate cross-contamination between samples caused by incomplete decontamination. Dedicated equipment can also increase sampling efficiency through the elimination of the need to decontaminate equipment for successive sampling. Furthermore, dedicated equipment can also help to reduce the physical handling of the equipment that can cause sample contamination through contact with potentially contaminated surfaces. New, disposable equipment may need to be decontaminated before use. Review project-specific planning documents regarding decontamination of disposable equipment.

5.1.2 Equipment Decontamination

Equipment that will be in contact with the sample must be decontaminated prior to or after each use. This is necessary to minimize inadvertent contamination of the sample. Specific methods for equipment cleaning are dependent upon a number of factors including the sample media, analytical parameters, the purpose of the investigation, the equipment to be cleaned, and the specific regulatory guidelines that may apply.

Equipment decontamination procedures are described in the Equipment Decontamination SOP (SOP-05r1). Any site specific decontamination procedures can be specified in the field sampling plan for each project.

5.1.3 Sequence of Sampling

Wells that are sampled with non-dedicated equipment should always be conducted in a sequence that proceeds from wells containing the lowest concentrations to wells containing the highest concentrations, where feasible. Sampling in this order will further minimize the likelihood of sample cross-contamination that can be caused through improper handling or equipment cleaning. . If water quality is not known, the wells up-gradient of a suspected source area should be sampled first, followed by the wells furthest away and cross-gradient or down-gradient.

5.2 Purging And Sampling Procedures

This section provides a description of the procedures to be used for groundwater sampling. These procedures include planning, preparatory office activities, preparatory field activities, well purging, well sampling, and post sampling activities. These activities are listed on Attachment A and are described in detail in the following sections. Many of these steps have record keeping components which are discussed in Section 5.3.

5.2.1 Planning

The planning phase should include the selection of specific field methods, including the well purging strategy and planning for the proper disposal of the purge water. The sampling program should be discussed in project-specific planning documents.

Good communication with the analytical laboratory is essential to the success of a groundwater sampling project. The analytical requirements must be well defined and clearly communicated, prior to conducting the field work. Written communication is encouraged, in particular to document requirements for specific analytical methods, low detection limits, and other special needs. Written communication should include a detailed scope of work that includes the quality assurance plan for the project. These plans should specifically identify detection limits, with particular emphasis placed on how these limits relate to regulatory criteria or risk based criteria that have been developed for the project.

Sampling Equipment Selection

Some of the factors that should be considered in the selection of sampling devices include:

- Well yield
- Depth to water
- Well diameter and depth
- Required material of construction
- Analytical parameters
- Regulatory requirements
- Cost

Attachment B summarizes well sampling equipment. Attachment C presents a matrix indicating suitability of sampling and purging equipment for specific applications.

Purging Strategies

The strategy that will be employed for well purging should be determined prior to sampling and presented in project-specific planning documents. Several different strategies are commonly used in order to assess the completeness of well purging. The most common purging strategies are listed below.

- Purging is continued until stabilization of certain indicator parameters is observed in successive measurements over a specified time or volume. The most commonly used indicator parameters include pH, specific conductivity, turbidity, temperature, oxidation/reduction potential (ORP), and dissolved oxygen (DO). This purging method is commonly used for low-flow sampling methods where the well is pumped at rates of < 500ml/min that do not induce drawdown and ostensibly mirror flow rates in the aquifer.
- Purging 3 to 5 well volumes of water from the well.
- Purging low yield wells until the water level reaches the top of the well screen or until dry, and then allowing the well to partially recover. After partial recovery, the well is re-purged to the top of the well screen and allowing the well to partially recover a

second time. It is recognized, however, that it may not be possible to avoid dewatering the well screen in many shallow wells.

- Wells that are operated continually or very frequently (e.g. pumpback wells, domestic wells or irrigation wells) require minimal purging only to ensure the sample line is cleared of stagnant water and fresh water is pumping from the well (typically 20-50 gals).

Purge Water Disposal

The methods and responsibility for collection, containerization, treatment and disposal of purge water should be determined prior to initiation of any sampling project. Much of how to handle purge water is discussed in the SOP for Investigation Derived Waste. However, additional considerations for groundwater purging and sampling are included below.

Collection and containment is often accomplished through use of 5 gallon containers, 55 gallon drums, mobile storage tanks, or through use of vacuum trucks which can directly transport to a treatment facility or to an evaporation pond on site. If specifically allowed by the responsible agency, purge water may be reapplied to the ground surface. Treatment of purge water may be accomplished on site at facilities that have wastewater treatment plants, or by using a mobile treatment unit. Responsibility for off-site disposal of containerized purge water must be determined prior to conducting the work.

5.2.2 Preparatory Office Activities

Equipment and containers should be organized in the office prior to embarking on a field sampling project to the extent practicable. The time spent in the field should be spent on sample collection, making field measurements and recording data.

Prepare Sampling and Purging Equipment

The purging and sample collection equipment and all required hardware should be obtained, organized and decontaminated prior to the initiation of the field sampling program. To accommodate waste generated during decontamination, these activities may be completed at the site prior to sampling.

Sample Containers and Preservatives

The appropriate sample containers and associated preservatives must be obtained. The containers and preservatives are normally, but not always, supplied by the laboratory that will be responsible for the analyses. Sample containers should be organized and inventoried several days prior to initiation of the sampling program in order to provide sufficient time to rectify any problems, should they occur. Whenever possible, pre-printed sample labels should be created prior to mobilization, if possible. Sample containers with acid preservatives should not be more than 6 months old and should have been stored in a clean secure location. Some preservatives may have an even shorter shelf life.

Initiation of Field Data Records

Field data sheets may be initiated prior to the start of sampling. Examples of initial data to be recorded include site and sampling location identification, well depth, purging and sampling collection methods and previous field data.

5.2.3 Preparatory Field Activities

The following procedures should be conducted in the field prior to well purging and sampling.

Well Maintenance Check

A well maintenance check should be performed that includes a visual inspection of the condition of the protective casing and surface seal. In addition, the well should be inspected for other signs of damage or unauthorized entry. Any problems should be documented.

It is recommended that the bottom of the well not be sounded each time the well is sampled. Routine sounding of the well can increase the risk of inadvertent well contamination because it is difficult to adequately decontaminate the tapes used for this purpose. Well depths obtained from well completion records are generally adequate for the purpose of the determination of well volume. Generally, the only reason to sound well depth is if a need to verify the depth arises, or if you suspect that sediment/soil has collected in the bottom of the well.

Preparation of Well Area

A suitable work area should be established around the perimeter of the well. Sampling equipment should be placed on a clean surface such that it will not become inadvertently contaminated. Remember – a clean work area leaves a much more favorable impression than a dirty work area.

Water Level Measurements

The depth to water should be measured and recorded prior to initiation of all sampling activities. The water level measurements should be made from the same marked point on the inner well casing each time. See SOP-16, Monitoring Well Water Level Measurements.

Calculation of Well Purge Volume

The volume of water standing in the well should be calculated through the application of the depth to water data, the known well depth, and the well diameter using the constants presented below. Well depth information obtained from the well completion records are generally sufficiently precise for the purpose of well volume calculations that would be used for subsequent purging determinations.

The following conversions allow quick calculation of well casing volumes:

Well Casing Diameter (inches)	Gallons per foot of water
1.0	0.041
2.0	0.163
3.0	0.367
4.0	0.653
6.0	1.469

Alternatively, the well casing volume may be calculated using the formula $V = CF*d^2h$, where

V = volume of water (gallons)

d = diameter of well (inches)

h = height of water column (feet)

CF = conversion factor (0.0408) that includes conversion of cubic feet to gallons, inches to feet, and diameter to radius.

Land Owner Notification and Communication

For domestic wells or monitoring wells that are located on property not owned by the client, landowners must be notified prior to sampling. The notification should be at least several days prior to the sampling event and should include the specific date and times that personnel will be on the property. Coordination as to who will contact the landowner should be done in advance. It should also be determined if a written agreement (e.g., a right-of-entry) between the client and the landowner prior to accessing the property is required. You may discuss the sampling procedure with the landowner, but do not discuss water quality results – especially their neighbor's water quality results. Do not offer any opinions about the site in your conversation with the landowner. The client has a fact sheet that lists what facts may be discussed with landowners; any topics not included on the fact sheet should be avoided. You may give the landowner the client's phone number and advise him to contact the client for more information.

5.2.4 Well Purging

Monitoring wells and domestic wells must be purged prior to the collection of aqueous phase samples. Specific instructions for the use of purging equipment are presented in Section 5.2.6.

The placement of a device (in most cases a pump) that will be used for well purging is critical in order to ensure a complete exchange of the entire water column. The intake of a device used for purging should be placed as high in the water column as is possible under pumping conditions. Optimum placement is to have the pump at the top of the water column. This is done so that purging will draw water from the formation into the screened area of the well, and up through the casing, so that the entire static water column can be removed. In monitoring wells, there is the flexibility to raise or lower the pump in the well to achieve optimum placement. In a domestic well, this is not the case because the well pump is fixed inside the casing to the surface making changes to the configuration infeasible.

If the monitoring well is a slow recharging well, then the pump should be placed near the surface and slowly lowered at a rate similar to groundwater withdrawal. As an alternative approach the pump could be set at no more than three to five feet below the water surface. If the recovery rate of the well is faster than the pump rate and no observable drawdown occurs, the pump can be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the well recovery rate, the pump will have to be lowered as needed based upon the amount of drawdown.

Low Stress or Low Flow Groundwater Purging

Sometimes it is desirable to collect representative samples while exerting minimum stress on the water-bearing formation. Typically this is accomplished by limiting the flow rate during purging to the range of 100 to 500 ml/min (0.025 to 0.13 gallons/min). For this procedure, the goal is to induce a steady flow rate while minimizing the drawdown.

It is important to insert the sampling equipment carefully, so as to prevent the re-suspension of silt and clay particles in the well. In order to minimize turbidity, it is preferable to use dedicated equipment, or to allow sufficient time after the installation of non-dedicated equipment to allow soil particles to re-settle before purging and sampling. Sufficient time for settling should be verified by turbidity measurements.

Initially, the purge flow rate should start at approximately 200 ml/min (0.053 gallons/min), and water level should be frequently monitored,(approx. once per minute for 5 minutes). Flow rate should be adjusted so that drawdown will not exceed 0.3 ft, or approximately 2 percent of the saturated thickness of low permeability formations, whichever is greater. If historical data from the well indicates there is no drawdown of the aquifer at the higher pumping rate of 500ml/min, then the purge rate can be established at this higher rate.

Groundwater parameters will be monitored in an air-tight flow cell equipped with a YSI-556 multi probe field meter (or equivalent). Field parameters will be monitored every five minutes, a frequency established to ensure a full volume change of water in the flow cell. Parameter based criteria include three consecutive readings that meet the following:

- Temperature: ± 3% RPD
- Conductivity: ± 3% RPD
- pH: ± 0.1 pH unit
- ORP: ± 10% RPD or ± 10 mV
- DO: ± 10% RPD or ± 0.1 mg/L if < 2mg/L (± 0.3 when < 1.0)
- Turbidity: < 10 NTU or ± 10% RPD if > 10 NTU

If these parameters have not stabilized after one hour, the sample may be collected and a note will be made in the field book or on the field data form.

Standard Purging Approach

Initially, groundwater withdrawal should occur no more than three to five feet below the water surface. If the recovery rate of the well is faster than the pump rate and no observable drawdown occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the well recovery rate, the pump will have to be lowered as needed based upon the amount of drawdown.

An adequate purge is normally achieved when three to five times the volume of standing water in the well has been removed. After three well volumes have been removed, if the chemical parameters have not stabilized according to the criteria given below, additional well volumes may be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project manager whether or not to collect a sample or to continue purging. If a sample is taken after five volumes and the field parameters have not stabilized, this situation will be noted in the field book.

Considering groundwater chemistry, an adequate purge is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). In very silty formations, the turbidity stabilization criteria given above may be impossible to reach and should be disregarded. Other parameters such as salinity, dissolved oxygen, and oxidation reduction potential also may be important criteria for stabilization, especially under low flow purging. Stabilization occurs when parameter measurements are within 10 percent between two readings spaced approximately one well volume apart, or under low flow purging, between two readings determined in project planning documents. A water quality meter fitted with a flow through cell, which allows continuous monitoring of the above parameters is recommended for these measurements.

Attempts should be made to avoid purging wells to dryness, as previously described. However, even with slow purge rates, a well may be purged dry. In those cases, this constitutes an adequate purge and the well can be sampled when recovery is sufficient (enough volume to fill the sample containers). Recovery criteria are often cited as 80 percent of the original well column height. The maximum recovery time prior to sampling should be 24 hours.

Domestic Well Purging

Domestic wells should be purged by opening the spigot and allowing a pre-determined amount of water (e.g., 20 gallons) to flow through. A spigot closest to the well house should be used for purging and sampling to minimize the amount of piping and reduce purge time. A spigot should be located that does not draw water from a water softener tank, the water should be drawn directly from the well.

5.2.5 Groundwater Sampling

It is important that wells be sampled as soon as possible after purging. If adequate volume is available, the well should be sampled immediately as long as the well has recovered to 80 percent of the original water column height. If not, sampling should occur as soon as the well has recovered sufficiently to provide adequate volume. Specific instructions for the use of sampling equipment are presented in Section 5.2.6.

Low Stress Groundwater Sampling

Sometimes it is desirable to collect representative samples while exerting minimum stress on the water-bearing formation. Typically this is accomplished by limiting the flow rate during sampling to the range of 200 to 500 ml/min (0.053 to 0.132 gallons/min). Sampling flow rate should not exceed the purge flow rate for which water quality indicator parameters stabilized. However, for certain locations a higher pressure may be required to push the sample water through the filter in order to maintain the same flow rate. Sampling equipment must be the same equipment that was used for purging, and should not be moved between purging and sampling activities.

Standard Sampling Approach

As with purging equipment, there are a number of considerations in the selection of sample collection equipment. Furthermore, it is common to use a different device for sample collection than for purging. An example would be to purge with the use of submersible pump and to collect the sample with the use of a disposable bailer. A summary of well sampling equipment is provided in Attachment B.

As discussed previously, consideration should be given to the order in which sample containers are to be filled for various parameter groups. The order should be determined on the basis of parameter sensitivity to volatilization, pH change, or oxidation, and the priority for analytical data in cases where the water volume in the well is less than what is required for analysis. In general, volatile organic compounds are the most sensitive constituents to volatilization so the sample for these parameters should be containerized immediately. Likewise, pH change occurs rapidly in samples that are in contact with air, so pH measurements and the containerization of pH sensitive parameters, such as anions (e.g., nitrate, sulfate), or metals, (e.g., ferrous iron or Fe2+), should also be implemented expeditiously.

Domestic Well Sampling

Sampling a domestic well requires minimal equipment since the domestic water supply system includes a pump and pressurization tank that delivers a reliable sample stream under pressure. Domestic well samples should be taken prior to in-line water filters or water softeners. Garden hoses should be removed prior to sampling.

5.2.6 Equipment Instructions

This section provides specific instructions for the installation and use of various devices for both well purging and groundwater sample collection, and includes the following equipment:

A. Gasoline powered-compressed air dedicated Bladder pump

B. Compressed gas-powered dedicated bladder pump
C. Direct current powered-compressed air dedicated pump
D. Small diameter (2-inch) electric submersible pump
E. Large diameter (4-inch) electric submersible pump
F. Gasoline powered dedicated production pump
G. Electrically powered submersible dedicated pump
H. Peristaltic suction pump
I. Domestic water supply system.

It is recognized that a combination of the procedures may be employed. An example would be the use of a small diameter electric submersible pump for purging and a bailer for sample collection. The specific methods to be used for purging and sampling a well should be outlined in the project-specific planning documents.

A, B & C Dedicated Bladder Pumps

A bladder pump is one of the easiest devices to operate for the purpose of purging and sample collection. The bladder pump is often dedicated to the well and can be used in conjunction with an inflatable packer in order to minimize the purge volume necessary to accomplish effective purging.

Required Equipment:

- Bladder pump
- Tubing of appropriate type and length
- Bladder pump controller
- Compressed inert air source
- New disposable gloves of appropriate material
- Graduated measuring container
- Purge water collection container
- Water quality monitoring equipment with flow through cell.
- Water level meter

Purging Instructions:

1) Refuel the gasoline-powered compressor, if used, at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site.

2) Place the gasoline-powered compressor as far from the well as possible in a down-wind direction to eliminate potential exhaust impact to sampling.
3) Take and record water level
4) Connect the compressed air source and pump controller to the pump as per manufacturer's instructions.
5) Don a new pair of gloves after handling the gasoline-powered compressor.
6) Determine the volume of water to be purged, as described previously.
7) Start the pump by opening the regulator on the controller, which allows compressed air to flow into the system.
8) The controller should be adjusted to maximize the flow rate while minimizing the rapid "jolting" of the tubing as water is drawn into pump.
9) Direct the pump discharge to the graduated measuring container and determine the pumping rate.
10) Collect purge water in container
11) Continue pumping until the necessary volume of water has been purged from the well.
12) Monitor indicator parameters as discussed previously.

Sampling Instructions:

1) Allow the well to recharge after completion of purging, if necessary.
2) Resume pumping after adjusting the regulator to the minimum pressure that will still allow water to be pumped to the surface.
3) Collect the samples by pumping directly into each of the required containers.
4) Bottles should be filled as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).
5) Filtered samples can easily be obtained by installing an in-line, 0.45 μm disposable cartridge filter directly onto the pump discharge.

D. Small Diameter (2") Electric Submersible Pump

A small-diameter electric submersible pump (Grundfos Redi-Flo2 or equivalent) can be operated with a wide variety of pumping rates such that it is very versatile for both well purging and sample collection. This type of pump can be used in either a dedicated or non-dedicated mode. Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

Required Equipment:

- Small diameter electric submersible pump
- Pump shroud (when used in a six-inch or larger well to minimize turbulence, to keep motor cool)
- Tubing of appropriate type and length
- Check valve (optional)
- Electric pump controller with appropriate power plug
- 230 volt, single phase, electric power source, >10 amps
- Tool kit including basic tools, tubing cutters, extra tubing connector bracket, electrical connectors, wire ties, etc.
- Ground fault interrupter (GFI)
- New disposable gloves of appropriate material
- Graduated measuring container
- Water quality monitoring equipment (preferably a flow through cell).

Installation Instructions:

1) Don a new pair of gloves.
2) Assemble the pump, tubing, optional check valve, and electric power cables.
3) Decontaminate equipment and pump (if not dedicated) as outlined in decontamination SOP (SOP-05).
4) Take and record water level.
5) Lower pump slowly into the well, being careful not to contact any surface other than the interior of the well or the plastic sheeting. When lowering the pump be particularly sensitive to areas that suggest drag or problems in the well where the pump could get stuck. If a problem exists do not continue, but discuss ways to investigate with PM or senior technical personnel.
6) Place the pump intake as discussed in Section 5.4.2. Monitor the pump discharge and well hydraulics as discussed previously.

Purging Instructions:

1) Refuel the electric generator if used at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site.
2) Place the gasoline-powered compressor if used as far from the well as possible in a down-wind direction to eliminate potential exhaust impact to sampling.
3) Don a new pair of gloves after handling the generator.

4) Connect to electric power,
5) Determine the volume of water to be purged, as described previously.
6) Start the pump.
7) Direct the pump discharge to the graduated measuring container and determine the pumping rate.
8) Collect purge water into appropriate containers
9) Continue pumping until the necessary volume of water has been purged from the well.
10) If the pump intake has been placed deeply down into the water column for some reason, slowly withdraw the pump upward through the water column while it is still running to purge all water standing above the pump unless the pump will be used for sample collection.
11) Shut off the pump rapidly whenever the pump stops pumping water.
12) Monitor indicator parameters as discussed previously.

Sampling Instructions:

1) Allow the well to recharge after completion of purging, if necessary.
2) Resume pumping and adjust the pumping rate to the slowest possible rate, if necessary.
3) Collect the samples by pumping directly into each of the required containers.
4) Bottles should be filled as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).
5) Filtered samples can easily be obtained by installing an in-line, 0.45 μm disposable cartridge filter directly onto the pump discharge.

E. Large Diameter (4") Electric Submersible Pump

A large-diameter electric submersible pump is most frequently used for purging large-diameter wells that cannot be efficiently purged using other methods. Large-diameter pumps can also be used for sample collection for parameters that are not particularly pH or pressure sensitive. This type of pump is usually not dedicated. Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

Required Equipment:

- Large-diameter, stainless steel electric submersible pump
- [Optional] Check valve, install internally within the pump or externally between the pump and the tubing

- Electric power cable on a plastic reel (Teflon® jacketed cable is preferred)
- Stainless steel or polypropylene support line
- 1/2" to 1" PE Tubing of appropriate length
- Flow control valve
- 120 or 240 volt electric power source (as appropriate)
- Ground fault interrupter (GFI)
- Tool kit including assorted basic tools, tubing cutters, wire cutters, hose clamps, waterproof connectors, wire ties, hose fittings, assorted pipe nipples and adapters, etc.
- New disposable gloves of appropriate material
- New plastic sheeting
- Five gallon pail, graduated in minimum one gallon increments or flow meter
- Bleeder tee (if the submersible pump is used for sample collection). This consists of a tee with a large diameter, valved pump discharge port and a Water quality monitoring equipment.
- small diameter, valved port equipped with a sample weephole.
- Water quality monitoring equipment (preferably a flow through cell).

Installation Instructions:

1) Place new polyethylene (PE) sheet on suitable surface adjacent to well, taking care not to step on the PE sheet.
2) Don a new pair of gloves.
3) Decontaminate equipment and pump (if not dedicated) as outlined in decontamination SOP.
4) Assemble the pump, tubing, flow control valve, electric power cables and support line and lower into well being careful not to contact any surface other than the interior of the well or the PE sheeting.
5) The tubing, electrical power cable and support line should be fastened together at 15 to 20 foot intervals with the use of nylon wire ties taking care to leave adequate slack in the electric power cable. Electrical tape is not preferred but can be used to secure the lines if the sample is not being analyzed for VOCs.
6) The use of a check valve is recommended to prevent rapid backflow of water from the tubing after the pump is shut off. It is recognized, however, that the use of a check valve makes it more difficult to pull the pump from the well due to the added weight of the water in the tubing and can increase the chance of "sand locking" occurring in the pump.

7) Lower pump slowly into the well, being careful not to contact any surface other than the interior of the well or the plastic sheeting. When lowering the pump be particularly sensitive to areas that suggest drag or problems in the well where the pump could get stuck. If a problem exists do not continue, but discuss ways to investigate with PM or senior technical personnel.
8) Place the pump intake as discussed in Section 5.4.2. Monitor the pump discharge and well hydraulics as discussed previously.

Purging Instructions:

1) Refuel the electric generator at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site.
2) Place the gasoline-powered compressor as far from the well as possible in a down-wind direction to eliminate potential exhaust impact to sampling.
3) Don a new pair of gloves after handling the generator.
4) Connect electric power and GFI to the pump.
5) Determine the volume of water to be purged, as described previously.
6) Start the pump.
7) Determine the pumping rate either by directing the pump discharge to the five gallon pail or with the use of a flow meter.
8) Adjust pumping rate to match the yield of the well.
9) Continue pumping until the necessary volume of water has been purged from the well.
10) If the pump intake has been placed deeply down into the water column for some reason, slowly withdraw the pump upward through the water column while it is still running to purge all water standing above the pump.
11) Shut off the pump immediately whenever the pump stops pumping water.
12) Dispose of the tubing and support line after use.
13) Monitor indicator parameters as discussed previously.

Sampling Instructions:

1) Allow the well to recharge after completion of purging, if necessary.
2) Resume pumping and adjust the bleeder tee valves so that a slow, steady, non-aerated flow emanates from the bleeder tee weephole (approximately 100 ml/min).
3) Collect the samples directly from the weephole into each of the required containers.
4) Bottles should be filled in order of sensitivity to volatilization and oxidation as discussed in Section 5.1.3 or as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).

5) Filtered samples can easily be obtained by installing an in-line, 0.45 µm disposable cartridge filter directly onto the pump discharge

F. Generator Powered Production Pump (WW-40 & WW-59)

Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

Required Equipment:

- New disposable gloves of appropriate material
- Gasoline generator
- Electrical connectors
- Grounding strap
- Five gallon pail, graduated in minimum one gallon increments
- Water quality monitoring equipment (preferably a flow through cell).

Purging Instructions:

1) Refuel the electric generator at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site.
2) Connect electrical connections to generator and to production pump controller.
3) Connect grounding strap from generator frame to well casing.
4) Determine the volume of water to be purged, as described above.
5) Start generator.
6) Direct the pump discharge to purge water away from roadway or generator.
7) Continue pumping until the necessary volume of water has been purged from the well.
8) Monitor indicator parameters hourly.

Sampling Instructions:

1) Don a new pair of gloves
2) Sample from sampling valve located on well discharge pipe.
3) Collect the samples by pumping directly into each of the required containers.
4) Bottles should be filled as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).

5) Filtered samples can easily be obtained by installing an in-line, 0.45 µm disposable cartridge filter directly onto the pump discharge sampling spigot.

G. Electrical Powered Submersible Dedicated Pump (Pumpback system)

The Pumpback Well system consists of 11 dedicated electrical submersible pumps. Since the pumps run frequently it is necessary to monitor parameters for stabilization or to follow purge procedures.

Purging Instructions:

1) Drive to well
2) Open valve box lid
3) Don new gloves.
4) Open check valve to begin purging.
5) Purge until discharge tube water is relatively clear.
6) Take parameter reading.

Sampling Instructions:

1) Collect the samples by pumping directly into each of the required containers.
2) Bottles should be filled as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).

G. Peristaltic Suction Pump

A peristaltic pump can be used to purge shallow, small diameter wells at a low to modest rate. The lift capacity is very limited with these pumps and often exceeded at groundwater depths of greater than 20 to 25 feet (depending upon pump size). This type of pump is normally used with dedicated tubing. Peristaltic pumps can also be used for sample collection for parameters that are not pH or pressure sensitive. Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

Required Equipment:

- Peristaltic pump, electric powered 12 VDC.
- 12 VDC power source, such as a sealed motorcycle battery or connection to vehicle battery.
- 3/8" to 1/2" PE, PP, or Teflon® tubing of appropriate length.

- 5/8" OD, 3/8" ID medical grade silicone tubing. Do not attempt to use Tygon® tubing.
- New disposable gloves of appropriate material.
- Graduated measuring container.
- Water quality monitoring equipment (preferably a flow through cell).

Installation Instructions:

1) Don a new pair of gloves.
2) Replace the silicone tubing in the pump head if the pump will used for sample collection.
3) Lower the tubing into the well, being careful not to contact any surface other than the interior of the well or the plastic sheeting.
4) Place the intake of the tubing as high in the well as possible but deep enough that it will not break suction.

Purging Instructions:

1) Connect the tubing to the pump.
2) Determine the volume of water to be purged, as described above.
3) Start the pump.
4) Collect purge water into container
5) Direct the pump discharge to the graduated measuring container and determine the pumping rate.
6) Continue pumping until the necessary volume of water has been purged from the well.
7) If the pump intake tubing has been placed deeply down into the water column for some reason, slowly withdraw the tubing upward through the water column while it is still running to purge all water standing above the bottom intake.
8) Dispose of the tubing after use.
9) Monitor indicator parameters as discussed previously.

Sampling Instructions:

3) Allow the well to recharge after completion of purging, if necessary.
4) Resume pumping and adjust to a slow pumping rate, (approximately 100 ml/min) if the pump is equipped with a speed control.
5) Collect the samples by pumping directly into each of the required containers.
6) Bottles should be filled in order or as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials.

Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).

7) Filtered samples can easily be obtained by installing an in-line, 0.45 µm disposable cartridge filter directly onto the pump discharge.

I. Domestic Water Supply System

Sampling a domestic well requires minimal equipment since the domestic water supply system includes a pump and pressurization tank that delivers a reliable sample stream under pressure.

Required Equipment:

- Graduated measuring container
- Water quality monitoring equipment (preferably a flow through cell).

Installation Instructions:

- None required.

Purging Instructions:

1) Following notification of the landowner (refer to Section 5.2.3), arrive at the location and immediately knock on the front door to see if anyone is home and to announce your presence. There is no reason to enter the home.
2) Don a new pair of gloves.
3) Go to the outside spigot closest to the well.
4) Remove the hose from the spigot. If necessary, the hose may be left on the spigot for purging, but it must be removed prior to sampling.
5) Turn on the spigot.
6) Measure and record the approximate purge flow rate (gpm) by conducting a bucket test.
7) Allow at least 20 gallons to flow through the spigot. Collect the water in the bucket and pour the purge water on the landscaping.
8) Monitor indicator parameters consisting of pH, specific conductivity, and temperature. The domestic water supply system is considered stabilized when three consecutive readings vary by less than 10% or pH changes by less than 0.1 pH units.

Sampling Instructions:

1) When at least 20 gallons have been purged and pH, specific conductivity, and temperature have stabilized, the domestic water supply system is ready to be sampled.

2) Collect the samples by filling the required containers directly from the spigot. The valve on the spigot should be turned almost to the closed position to provide a low sampling flow rate that is as laminar as possible.
3) Bottles should be filled as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).
4) Filtered samples can easily be obtained by installing an in-line, 0.45 µm disposable cartridge filter directly onto the spigot.
5) Turn off spigot and re-attach hose.

5.2.7 Field Measurements

The final determination of pH, specific conductance, and temperature should be made immediately upon collection of the samples. It is preferred that these parameters be measured continuously using a water quality meter coupled with a "flow through" cell. Alternately, these measurements would be made in an aliquot contained in a disposable plastic cup.

5.3 FIELD RECORDS

Accurate field records must be maintained to document groundwater sampling activities. These records include technical field data, sample identification labels, and chain-of-custody information for each sample. These records are described in detail in the following sections, and discussed in the Field Documentation and Sampling Handling SOPs (SOP-03r1 and (SOP-01r1).

Specifically for groundwater sampling, the field sampling records (Field Logs) should include, at a minimum, the following information:

- Sampling location
- Date and time
- Condition of the well
- Static water level (depth to water)
- Calculated well volume
- Purging method
- Actual purged volume
- Sample collection method
- Sample description
- Field meter calibration data

- Water quality measurements
- General comments (weather conditions, etc.)

All data entries should be made using black indelible ink and should be written legibly. Entry errors should be crossed out with a single line, dated, and initialed by the person making the correction.

5.4 SAMPLE SHIPMENT

Shipment of samples to an analytical laboratory is usually required upon completion of sample collection. Proper packaging is necessary in order to protect the sample containers, to maintain the samples at or below a temperature of 4°C, and to comply with all applicable transportation regulations. See the Sampling Handling and Management SOP (SOP-01r1) for further details.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

In order to assess the accuracy and precision of the field methods and laboratory analytical procedures, quality assurance/quality control (QA/QC) samples are collected during the sampling program according to the project Work Plan. QA/QC samples may be labeled with QA/QC identification numbers or fictitious identification numbers if blind submittal is desired, and are sent to the laboratory with the other samples for analyses. The frequency, types, and locations of QA/QC samples are specified in the project QAPP or Work Plan. Examples of QA samples include, but are not limited to, equipment rinsate blanks, field blanks, trip blanks, filter blanks, duplicate samples, and matrix spike/matrix spike duplicate samples.

6.1 Equipment Rinsate Blanks

An equipment rinsate blank is intended to check if decontamination procedures have been effective and to assess potential contamination resulting from containers, preservatives, sample handling and laboratory analysis. Procedures for collection are as follows:

1. Rinse the decontaminated sampling apparatus with deionized water. Allow the rinsate to drain from the sampling apparatus directly into the sample bottle or into a secondary container which is then poured into the sample bottle;
2. Add any preservatives associated with the sample analytical methods to the rinsate sample;
3. Specify (on the COC) the same analytical methods for rinsate samples as is specified for the groundwater samples;
4. Assign the rinsate sample an identification number and label as rinsate samples; and
5. Place the rinsate sample in a chilled cooler and ship it to the laboratory with the other samples.

An Equipment Rinsate blank sample will be collected for every 20 samples (or less) each day samples collected using equipment is used.

6.2 Field Blanks

Analyses of field blanks are used to assess the contamination of samples during sample collection. Field blanks are prepared at a sampling location by pouring certified analyte-free water provided by the laboratory into a preserved container. The field blank sample should be analyzed by the same methods as the groundwater sample. An identification number shall be assigned and recorded in the log book which groundwater sample location the field blank was prepared at. A field blank will be collected and analyzed for every 20 investigative samples that are collected.

6.3 Trip Blanks

Trip blanks are volatile organic samples that are prepared in the laboratory using analyte-free water. Trip blanks are analyzed to assess VOC contamination of samples during transport and are used only when VOCs are suspected and being analyzed in the groundwater samples. One trip blank (three 40 ml vials) will be included for each cooler that contains samples for VOC analysis. At no time should the trip blanks be opened by field personnel.

6.4 Filter Blanks

Filter blanks are used to assess potential contamination introduced during the field filtering of samples from the filter media and are applicable only if the sampling event requires filtering of water samples. Filter blanks are collected by passing certified analyte-free reagent water provided by the laboratory through a clean filter similar to that used during the sampling event and from the same filter batch provided by the supplier. The collected filter blank sample shall be analyzed by the same methods as the groundwater samples. A minimum of one filter blank should be collected during each sample event for each batch of filters used.

6.5 Duplicate Samples

Duplicate samples are collected to assess the precision of field and laboratory components of field samples. When collecting a duplicate groundwater sample, the original and duplicate sample containers should be filled simultaneously, or as close to simultaneous as possible, by moving the discharge tubing or bailer back and forth over each container until they are full. Alternatively, the sample could be collected in one larger container, mixed, and split into the original and duplicate samples. This method will give a more representative split but also is more likely to introduce contamination if the larger container is reused and is therefore not preferred.

To maximize the information available in assessing total precision, collect duplicate samples from locations suspected of the highest contaminant concentration. Use field measurements, visual observations, past sampling results, and historical information to select appropriate locations for duplicate analyses.

The duplicate sample is handled and preserved in the same manner as the primary sample and assigned a sample number, stored in a chilled cooler, and shipped to the laboratory with the other samples. Whenever possible, the sample identification numbers for the characteristic sample and its duplicate are independent such that the receiving laboratory is not able to distinguish which samples are duplicates prior to analysis.

One duplicate sample shall be collected per 10 (or less) investigation samples.

6.6 Matrix Spike/Matrix Spike Duplicate Samples

An extra volume of sample media may be collected during the sampling event for performance of matrix spike (MS)/matrix spike duplicate (MSD) analyses by the laboratory to assess laboratory accuracy, precision, and matrix interference. Following shipment of the samples to the laboratory, the laboratory prepares MS and MSD samples by splitting the material into three separate sets of containers and spiking the split samples with appropriate analytes prior to performing the extraction in order to evaluate the total of the spiked compound and whatever quantity of the compound may be present in the sample. Results of the analyses are compared with the results of the primary sample and the known concentrations of the spike compounds. The percent recovery and relative percent difference are calculated and results are used to evaluate the precision and accuracy of the analytical method for various labeled "extra volume samples for MS/MSD." The sample volumes required for these analyses should be coordinated with the laboratory and are described in the project Work Plan.

At least one set of MS/MSD samples will be analyzed per 20 (or less) samples received.

7.0 REFERENCES

American Society for Testing Materials. "D 4448, Standard Guide for Sampling Groundwater Monitoring Wells."

Barcelona, M.J., J.P. Gibb, J.A. Helfrich and E.E. Garske, 1985. Practical Guide to Groundwater Sampling, Illinois State Geological Survey Contract Report 374, pp. 94.

Gibb, J.P., R.M. Schuller and R.A. Griffin, 1981. Procedures for the Collection of Representative Water Quality Data from Monitoring Wells. Illinois State Water Survey Cooperative Groundwater Report 7.

Gibb, J.P., R.M. Schuller, and R.A. Griffin, 1980. Monitoring Well Sampling and Preservation Techniques, EPA-600/9-80-101.

Gibs, Jacob, and Thomas E. Imbrigiotta, 1990. "Well-Purging Criteria for Sampling Purgeable Organic Compounds," Ground Water, vol. 28, no. 1.

Herzog, B., J. Pennino, and G. Nielsen, 1991. "Ground-Water Sampling," Practical Handbook of Ground-Water Monitoring, David M. Nielsen editor, Lewis Publishers, Chelsea, MI, pp. 449-499.

NCASI, 1982. "A Guide to Groundwater Sampling", NCASI Technical Bulletin, No. 362, January 1982.

New Jersey Department of Environmental Protection, 1988. Field Sampling Procedures Manual, pp. 414

Scalf, M.R., J.F. McNabb, W.J. Dunlap, R.L. Cosby, and J.S. Fryberger, 1981. Manual of Ground-Water Quality Sampling Procedures, September 1981, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, EPA-600/2-81-160.

Schuller, R.M., J.P. Gibb, and R.A. Griffin, 1981. "Recommended Sampling Procedures for Monitoring Wells," Ground Water Monitoring Review, Spring 1981, pp. 42-46.

United States Environmental Protection Agency Region IV, 1996. Environmental Investigations and Standard Operating Procedures and Quality Assurance Manual, 1996, pp. 7-1 - 7-10.

United States Environmental Protection Agency, 1991. Compendium of ERT Groundwater Sampling Procedures, EPA/540/P-91/007, January 1991.

8.0 ATTACHMENTS

Attachment A - Groundwater Sampling Checklist

Attachment B – Groundwater Sampling Log – Purge Method

Attachment C – Groundwater Sampling Log – Low Flow Method

ATTACHMENTS

Attachment A. Groundwater Sampling Checklist

Planning

Preparatory Field Activities

- ☐ Perform well maintenance check.
- ☐ Prepare clean work area.
- ☐ Determine the depth to groundwater (±0.02 ft).
- ☐ Calculate the water volume standing in the well (±2%).

Well Purging

- ☐ Place purging device at proper depth to ensure complete purging of well (if device is not also used for sample collection).
- ☐ Purge well, following previously selected strategy.
- ☐ Handle and dispose of purge water using previously determined method.

Well Sampling

- ☐ Collect groundwater sample.
- ☐ Fill containers and made field determinations in order of decreasing sensitivity to volatilization and/or pH change.
- ☐ Fill all other sample containers.
- ☐ Record all technical data.
- ☐ Maintain chain of custody records.
- ☐ Pack and ship samples to prevent breakage, to maintain sample temperature of 4°C and to comply with Dangerous Goods regulations.

Attachment B. Summary of Well Sampling Equipment

Attachment B. Summary of Well Sampling Equipment

Description	Well Diam. (inches)	Depth Limit (feet)	Can it be Dedicated?	Materials	Reduce Flow to 100ml/m?	Acceptable for: VOC	Acceptable for: pH Sensitive	Advantages	Disadvantages	Manufacturers
Bailer										
Tube with bottom and/or top check valve, suspended by line.	Unlimited	Unlimited	Yes	• PVC • Teflon ® • HDPE • SS	Yes	No	Yes	• Simple, inexpensive • Can yield high quality samples if used carefully • No power required • Easily cleaned	• Awkward to use • Can aerate sample if not used carefully • Increases chance of turbid samples • Flow not continuous	Timco: Johnson: Voss:
Small Diameter (2") Electric Submersible Pump										
Electrically driven impeller pump.	2 - 4	400	Yes	• SS / Teflon ®	Yes	Yes	Yes	• Easy to operate • Easy to control • Continuous flow	• High capital cost • Awkward if not dedicated	Grundfos
Large Diameter (4") Electric Submersible Pump										
Electrically driven impeller pump.	>=4	unlimited	Not typically	• SS	No	No	No	• Continuous flow	• May not be compatible with VOC & pressure sensitive parameters	Grundfos
Peristaltic (Suction) Pump										
Elastic tubing that is sequentially squeezed by rollers.	<=2	± 25	Yes, internal elastic tubing & pump tubing	• Teflon ® • HDPE • PP	No	Yes		• Flow rate easily controlled, continuous • Portable • Inexpensive • No pump contact with sample	• Loss of VOC due to reduced pressure • Requires power source • May require priming • Can impede access	Isco, Masterflex

Notes:

SS: Stainless Steel
HDPE: High density polyethylene
VAC: Voltage AC Source
PVC: Polyvinyl Chloride
VOCs: Volatile Organic Compounds
PP: Polyprplene

Attachment C -Groundwater Sampling Log-All Methods

Groundwater Sampling Log

Project: Yerington Mine Site, NV
Client: Atlantic Richfield
Project #:

Event:
Date:

Well ID:
Static Water Level:

BROWN AND CALDWELL

Time		Pump Rate	Vol removed	Temperature		SC		DO		pH		ORP		Turbidity		Depth to Water	
	min	ml/min	Liters	Deg C	%RPD	uS/cm	%RPD	mg/L	%RPD or Δ	SU	Δ	mV	%RPD or Δ	NTU	%RPD	Ft	Drawdown
Previous event field parameters:																	
Criteria	60 max	100-500 ml/min		3%		3%		10% or Δ0.1 mg/L if <2.0		Δ 0.1 pH		10% or Δ10mV		< 10 NTU or 10%		<0.3 ft or 2% of aquifier	

Sample Date and Time:

Sampler:

		Analysis Requested:	Volume:	Filtered	Preservative:
	X	Dissolved Metals	500 ml	Y	HNO3
	X	Radionuclides	7L	Y	HNO3
	X	TDS, ph, Alkalinity Sulfate, Nitrate/Nitrite	500 ml	N	NONE
	X	TOC	250 ml	N	HCl
	X	Orthophosphate	500 ml	Y	H2SO4

		QC Sample ID:
		Duplicate
		MS/MSD
		Field Blank
		EQ Rinsate Blank

Pump Information:

Dedicated	Non-Dedicated	Pump deconned before use: Y N NA
		Bladder pump: DC gasoline nitrogen gas
		PSI: Refill: Disch:
		Geosquirt
		Production Pump
		Redi-Flo
		Other:

Comments:

$$\%RPD = 200 \times \frac{\text{Read 1 - Read 2}}{\text{Read 1+ Read 2}}$$

3 consecutive stable readings before sampling

Field Review:

QAQC Review:

SOP-11
Soil Sampling

Yerington Mine Site
Standard Operating Procedure

Revision 0
Revision Date: June 6, 2006

SOP-11
SOIL SAMPLING

TABLE OF CONTENTS

1.0 PURPOSE

The objective of this standard operating procedure is to provide standardized methods for the field collection of soil samples using manual or rig-assisted techniques.

2.0 SCOPE AND APPLICABILITY

This procedure specifies the methods to be followed by the field personnel for the collection of surface and subsurface soil samples. The collection techniques and equipment selected are dependent on the nature of subsurface soil conditions (i.e., degree of consolidation and moisture content), depth of the desired sample, type of sample required, type of soil being sampled, and analytical and/or geotechnical laboratory testing methods that will be requested for the sample.

Soil samples are used to determine the physical, hydrogeologic, and chemical properties of site soil. Analytical data aid in the characterization of the site, identification of hazardous substance source areas, and determination of the nature and extent of contamination. Typically a project Work Plan will be prepared that details sample locations, numbers, analytical methods, and specific field techniques that may be required. Different SOPs will be referenced in the Work Plan to provide detailed descriptions of how each procedure will be conducted. The project Work Plan may or may not include a field sampling plan (FSP) and Quality Assurance Project Plan (QAPP) based on client requirements. Proper sampling techniques, proper selection of sampling equipment, and proper decontamination procedures as outlined in the project Work Plan eliminates cross-contamination and introduction of contaminants from external sources.

Detailed records will be maintained during sampling activities, particularly with respect to location, depth, color, odor, lithology, hydrogeologic characteristics, and readings derived from field monitoring equipment. These records will be prepared following the SOP for Field Documentation. All soils are classified in the field by a geologist, hydrogeologist, or soil scientist using the Unified Soil Classification System (USCS), and as described in the SOP for Field Classification and Description of Soils. Color of the samples is determined in the field using a Munsell Color Chart.

3.0 RESPONSIBILITIES

The *Project Manager* develops or directs the preparation of a Work Plan, which describes the sampling procedures to be used and ensures that the procedures achieve the objectives of the investigation.

The *Field Supervisor* ensures that soil samples are collected according to procedures outlined in the project Work Plan or provides rational and justifiable decisions in circumstances where deviations from the project Work plan are necessary due to field conditions or unforeseen problems. The field supervisor also ensures that samples are handled, labeled, and shipped according to procedures outlined in the project Work Plan.

Field personnel are responsible for implementing this SOP as stated, and following the Work Plan requirements for sampling, QA/QC sample collection and frequency, and following other SOPs for field sample shipment and handling.

4.0 DEFINITIONS

Surface soil is generally considered to be the top 6 inches of a soil horizon profile (i.e., soil from 0-to-6-inches below ground surface [bgs]). Depending on the program or project, however, soil to 2 feet bgs may be considered surface soil. For the purposes of this procedure, surface soil represents the soil occurring from 0- to- 6-inches bgs.

Subsurface soil represents the soil occurring between surface soil and bedrock.

Composite soil samples are combinations of aliquots collected at various sample locations, or at various depths at a single location. Analysis of composite samples yields a value representing an average over the various sampled sites or depths from which individual samples were collected.

Discrete soil samples are discrete aliquots from distinct sampling intervals, of a specific size, that are representative of one specific sample location at a specific point in time.

Continuous samplers are devices that allow a soil specimen to enter a split barrel during drilling. Both plastic and steel liners can be used inside the sample tube to retain the sample. In some formations, the soil sample may be considered "undisturbed."

Split-barrel samplers collect samples by driving a 1.5-inch nominal inner diameter (typical), split barrel into a soil formation with a 140-pound hammer dropped 30 inches. For environmental applications, 2-, 2.5- and 3-inch inner diameter split barrels are not uncommon. If a standard 1.5-inch split barrel is used, the number of blows to drive the last 1 foot of the sample are referred to as the standard penetration resistance or N-value. See ASTM D-1586 for the specification for this type of sampler. Another type of split barrel sampler is the core barrel. A core barrel is longer and usually wider in diameter than the typical split barrel samplers and used on hollow stem auger drill rigs. Core barrels are usually 5 feet long and approximately 4-inch outside diameter, which sit into the leading auger and collect soil while drilling. Core barrels are typically unlined.

Ring-lined samplers are split barrels lined with removable rings. The rings are thin-walled and arranged in 1-, 2- or 6-inch increments to section the recovered soil sample. This device is used to collect soil samples for environmental applications and to collect relatively undisturbed soils in stiff and hard cohesive soils where it is not possible to push a sampler. See ASTM D3550 for the specification for this type of additional sampler.

Thin-walled tubes are used to recover relatively undisturbed soil samples by pressing the tubes into soil either hydraulically, or with a Denison or Pitcher sampler.

5.0 REQUIRED MATERIALS

Equipment used during manual collection of surface or subsurface soil samples may include a wide variety of tools depending upon the type of sampling and methods being used. This equipment can include, but is not limited to the following:

- Hand lens
- Stainless steel spoons/trowels and stainless steel hand augers

- Stainless steel split-spoon, split-barrel or continuous sampler
- Brass or stainless steel sampling sleeves, if applicable
- Encore™ Sampler T-bar and samplers (5 gram or 25 gram size), if applicable
- Field Balance accurate to 0.01 gram and VOA vials, and preservatives for field preservation of VOC vials under EPA 5035, if applicable
- Stainless steel bowls and pans, if applicable
- Silicon Tape, strapping tape, duct tape
- Field notebook or logbook
- Ball point pen
- Paper towels or Kimwipes
- Aluminum foil
- Teflon sheets
- Appropriate decontamination equipment
- Appropriate health and safety equipment
- Appropriate sample containers and labels, sample coolers and ice
- Chain of Custody forms
- Munsell soil color charts and grain size charts

6.0 PROCEDURE

This section identifies important preparations that should be made before initiating a soil sampling event and describes the steps that should be followed during soil sample collection at environmental sites.

Surface soil samples are defined in this procedure as samples collected from 0 to 6 inches below ground surface (bgs) or the first 2 inches of soil below a surficial layer of vegetation. These samples can be obtained easily using manual methods (i.e., a spade, trowel and scoop, or hand-auger). Surface soil samples can also be obtained with the assistance of a drilling rig equipped with a split-barrel sampler. The split-barrel sampler may be either unlined or lined with brass or stainless steel thin-wall sleeves.

Subsurface soil samples to be collected from depths greater than 6 inches bgs can be obtained manually using a hand-auger, a drilling rig, or excavating device (e.g., backhoe). A split-barrel sampler can be employed to depths in excess of 100 feet bgs with the assistance of a drilling rig. An excavating device can provide bulk soil samples from the ground surface to the limits of the excavator (typically 15 to 25 feet bgs . For bulk soil sampling at greater depths in unsaturated soils, a bucket auger rig may be used.

Composite soil samples are combinations of aliquots collected at various sample locations, or at various depths at a single location. Analysis of composite samples yields a value representing an average over the various sampled sites or depths from which individual samples were collected. Composite soil sampling is typically used in sampling soil for the characterization of investigation derived waste for disposal purposes. Other uses of composite sampling is in characterization of large surface area where a material may have been distributed.

6.1 Preparation for Soil Sample Collection

Preparation for the field collection of surface and subsurface soil samples shall commence with an assessment of ground surface conditions (e.g., undeveloped, vegetated or not vegetated, paved or unpaved, type and thickness of any pavement present) and subsurface conditions (e.g., soil types present, degree of consolidation, moisture content, depth of groundwater). Information available to assess these conditions may include regional soil survey reports by the USDA Natural Resources Conservation Service and/or borehole or test-pit/trench logs maintained during previous geological, geotechnical, or environmental investigations.

If a point designated for soil sample collection is overlain by abundant vegetation, it may be necessary to clear the area before sampling to provide access. If the sampling point is overlaid with concrete pavement, it is necessary to arrange for a cement cutter/corer to remove the paving material prior to sampling (cement cutting services are available through construction support or drilling subcontractors).

Prior to field collection of soil samples, the Project Manager (PM), Task Manager (as appropriate), and field personnel shall also perform the following tasks.

- Conduct a general site reconnaissance in accordance with the site-specific safety and health plan.
- Mark or identify all sampling locations using stakes, markers, or flags. If required, a proposed sampling location may be adjusted based on access, property boundaries, surface obstructions, and subsurface utilities.
- Determine the extent of the monitoring and sampling effort, analytical methods to be requested for each sample, sample container types required, sampling methods to be used, and specific equipment and supplies necessary to conduct the monitoring and sampling.
- Prepare all field forms as appropriate (field logbooks, pre-prepared Chain of Custody records and labels, etc.)
- Determine required monitoring equipment (e.g., photoionization detector, vapor detection tubes) and personal protective equipment (PPE) required for the health and safety of personnel.
- Obtain the necessary sampling and monitoring equipment and ensure it is in working order.
- Prepare field sampling schedules, provide these schedules to the client (if required), subcontractors, and regulatory agencies (if required), and coordinate field sampling activities with their designated representatives.

- Perform an underground utility clearance of all staked sampling locations prior to excavating or drilling.

6.2 Manual Soil Sample Collection

The following sections describe the specific steps that the environmental engineer/geologist shall follow when collecting surface and subsurface soil samples.

6.2.1 Collection of Surface Soil Samples

Tools such as spades, shovels, trowels, scoops, or spoons can be used to collect most surface soil samples, however, the sampler should be certain the sampling tools are not made out of a material that may effect the sample results (e.g., galvanized metal should not be used to collect metals samples and plastic should not be used to collect semivolatile organic samples).

For densely packed soils, and to collect discrete surface soil samples, it may be necessary to use a hand auger (Section 6.2.2), or a drilling rig (Section 6.3). Also, if relatively undisturbed samples are required, a flat, pointed, mason trowel can be used to cut a block sample of the desired soil. The procedure is as follows:

1. Prior to beginning sampling, don clean disposable nitrile or latex surgical gloves and impervious outer gloves to prevent cross-contamination and to provide personal protection. New gloves should be donned for sample collection at each new location or whenever gloves are torn or otherwise compromised.
2. Carefully remove the top layer of vegetation, soil or debris to the desired sample depth with a decontaminated spade, shovel, or equivalent.
3. Using a decontaminated, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area that came in contact with the spade. Also discard any pebbles, roots and other large objects that may be present in the sample material.
4. If a composite sample is required, place the sample into a stainless steel or other appropriate container and mix thoroughly to obtain a homogenous sample representative of the entire depth interval sampled. However, volatile organic samples are the exception; samples being analyzed for volatile organic compounds must be taken from discrete locations prior to mixing. This practice is necessary to prevent loss of volatile constituents and to preserve, to the extent practicable, the physical integrity of the volatile fraction. The process of homogenization is described below. After homogenization, place the sample into an appropriate container, as specified in the project Work Plan, and secure the cap tightly.
   - NOTE: If the sample is to be analyzed for volatile organic compounds (VOCs), transfer a portion of the sample directly (i.e., without homogenization) into the appropriate sample container with a stainless steel spoon, plastic spoon, or equivalent, and secure the container cap tightly. The sample container should be sealed with Teflon sheeting and capped with

rubber caps in order to prevent VOCs from escaping. Alternatively, sampling using EPA Method 5035 may be used (Section 6.4).

- Place a sample from each sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into the appropriate sample container(s) and secure the cap tightly.

5. Homogenization of the sample for remaining parameters may be necessary to create a representative sample volume if sample heterogeneity is not being evaluated. Moisture content, sediments, and waste materials may inhibit the ability to achieve complete mixing prior to filling sample containers. Therefore, when homogenization is requested, it is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is a representative as possible of the sample location. When homogenization is requested, the following procedure should be followed:

   - The soil is extruded from the sampling apparatus (i.e., drive sampler) or collected by a stainless steel trowel and emptied into the decontaminated stainless steel tray or bowl. Homogenization should be accomplished by then mixing with a decontaminated stainless steel or Teflon® instrument.
   - The method of choice for mixing is referred to as quartering and can be performed in a bowl or tray of an appropriate material (material depends on the parameters to be analyzed for). The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over.
   - The extent of mixing required will depend on the nature of the sample and should be done to achieve a consistent physical appearance prior to filling sample containers.
   - Once mixing is completed, the sample should be divided in half and containers should be filled by scooping sample material alternatively from each half.
   - Potential Problems
     (1) The higher the moisture or clay content, the more difficult it is to homogenize the sample.
     (2) A true homogenization of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions.

6. If a composite sample is not required, then the soil can be transferred directly into the sample containers. Attach a sample label to the container using the sample numbering system described in the Project Work Plan and the sample identification numbers generated for the specific locations.

7. Describe the sample following procedures outlined in the SOP for Soil and Rock Descriptions (SOP-12).

8. Record required field logbook and sample custody information as specified in the SOP for Field Documentation (SOP-03). Package the samples and prepare for transfer or shipment in accordance with the SOP for Sample Handling (SOP-01).
9. Mark the sample location with a numbered stake or other type of marker. If possible, photograph the sample location.
10. Sketch the sample location in the field logbook. If the proposed sampling point was relocated due to conditions encountered in the field, indicate both the original and actual sample locations on the site map, and record the reason for its relocation in the logbook.
11. Decontaminate sampling equipment in accordance with the SOP for Equipment Decontamination (SOP-05).
12. After a sampling round is complete, survey all sample locations to determine the ground surface elevation and horizontal coordinates, if required.

6.2.2 Soil Sampling with a Hand Auger

The equipment used for this manual method of soil sampling consists of an auger, a series of extensions, and a T-handle. The auger is used to bore a shallow hole to the desired sampling depth. The auger is then withdrawn, and the sample is collected by inserting a manual drive sampler (split-barrel) with brass or stainless steel sampler sleeves, and driving ahead of the auger hole. The typical sampler is a single shoe that contains one 6-inch sleeve or two 3-inch sleeves. Several types of hand augers are available, including tube, continuous-flight (screw), and posthole augers.

- With continuous-flight augers, the sample can be collected directly from the flights. Continuous-flight augers are satisfactory for use when a composite of the complete soil column is desired. This is not appropriate for depth discrete sampling.
- Posthole augers have limited utility for sample collection because they are designed to cut through fibrous, rooted, and/or swampy soils.

The following procedure is provided for manual collection of soil samples with a tube auger, as shown in Attachment A.

1. Don clean disposable nitrile or latex surgical gloves to prevent cross-contamination and to provide personal protection. New gloves should be donned for sample collection at each new location or whenever gloves are torn or otherwise compromised.
2. Check and clear each subsurface soil sample location prior to intrusive activities using as-built drawings, geophysical surveys (e.g. ground penetrating radar), or have clearances performed by the local utility company.
3. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). If a surface soil sample is to be collected, the environmental engineer/geologist shall follow the procedure for surface soils presented in Section 6.2.1. Before advancing the auger, it may be advisable to remove the first 3 to 6 inches of surface soil over a radius of approximately 6 inches around the borehole.

4. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.
5. Begin augering, periodically removing and depositing accumulated soils into an appropriate investigation-derived waste storage or transfer container. Temporary storage on plastic sheeting is appropriate, if identified in a project Work Plan or Waste Management Plan.
6. After reaching the desired depth, slowly and carefully remove the auger from the borehole.
7. Decontaminate the split-barrel sampler and sleeves (if required) in accordance with the SOP for Equipment Decontamination (SOP-05). Place the decontaminated sampler sleeve(s) into the sampler barrel. The sampler barrels are generally 6 inches in length and can hold one 6-inch or two 3-inch sleeves. Assemble the sampler by aligning both sides of the barrel and then attaching the drive shoe and head to the barrel's bottom and top, respectively. Some drive samplers are a two-piece unit – the shoe, which contains the sleeve and the head. For these samplers, the head is aligned with the shoe and threaded onto the head. The impact driver is threaded onto the head. Extensions may be added between the impact driver and the sampler for depths greater than 2 feet.
8. If a lined soil sampler is to be used, decontaminate the sample sleeves and store decontaminated sample sleeves in aluminum foil or on clean plastic sheeting as project requirements dictate prior to assembling the split-barrel sampler.
9. Carefully lower the drive assembly into the borehole, then drive it until the sleeve(s) are advanced into the undisturbed soil below the borehole.
10. Retrieve the sampler from the borehole and disassemble it. Remove the sample from the unlined sampler and transfer it to the appropriate container(s) or remove the sleeve from the sampler, and submit each sample sleeve as stipulated in the Project Work Plan.
11. For sample sleeves, seal the ends of each sample sleeve with Teflon™ sheeting and tightly fitting plastic end caps. The end caps shall then be held in place with silicone tape or other U.S. EPA-approved sealing tape. Electrical or duct tape shall not be used.
12. For sampling using EPA Method 5035, samples may be collected directly from the middle or bottom sleeve with the EnCore™ sampler, or aliquots placed into VOA vials and preserved as discussed in Section 6.4.
13. If another sample is to be collected at a greater depth in the same borehole, reattach the auger bit to the drill and assembly, and follow the steps above. Decontaminate the auger between samples.
14. Attach a sample label(s) to the container(s) using the sample numbering system described in the Project Work Plan and the sample identification numbers generated for the specific locations.
15. Abandon the borehole according to applicable state, county, and local regulations and the SOP for Borehole Abandonment and Monitoring Well Destruction (SOP-08).
16. Follow Steps 7 through 12 of Section 6.2.1.

If vertical composite samples are desired, aliquots of soil should be collected at more than one sampling depth and placed in a single collection container prior to mixing. Mixing is then performed using the procedures outlined in the surface soil composition section (Section 6.2).

6.3 Subsurface Soil Sampling with a Drilling Rig

Most often, when subsurface soil sampling is required at depths exceeding 5 feet bgs, a drilling subcontractor is used to help obtain the samples. Several drilling methods may be employed to collect the samples. Regardless of the drilling method, a 2-inch or 2.5-inch internal diameter split-barrel sampler (Attachment B) is often used to collect samples at depth. The split barrel sampler is attached to the appropriate drive-weight assembly, is positioned at the desired sampling depth and driven by repeated blows of a 140-pound hammer with a free-fall of 30 inches in general accordance with ASTM D1586 or with a pneumatic air hammer. Generally, split-barrel samples are 18 inches in length, but longer samples are also available.

Soil samples to be submitted to an analytical laboratory for testing may be collected in an unlined split-barrel sampler and transferred to sample containers as appropriate for shipment to the laboratory. However, the preferable method is to collect soil samples using a split-barrel sampler lined with thin-wall brass or stainless steel sleeves. This method allows for the collection of samples for chemical and physical properties or geotechnical analysis. Soil samples to be analyzed for metals shall be collected in stainless steel sleeves. Six-inch, 3-inch, or combinations of both sizes of sleeves can be used to line the split-barrel sampler. The procedures are outlined in the following sections.

Some of the procedures included in the following subsections are performed by the drilling subcontractor. Any procedure that deals with the apparatus (e.g. drill rig, split barrel samplers, drill rods) and services (e.g. drilling the boring and collection of soil samples) provided by the drilling subcontractor is operated by that subcontractor, who is qualified to do so.

6.3.1 Split-barrel sampler

1. Don clean disposable surgical nitrile or latex gloves to prevent cross-contamination and to provide personal protection. New gloves should be donned for sample collection at each new location or whenever gloves are torn or otherwise compromised.
2. Clear the ground surface of any surface debris (e.g., twigs, rocks, litter) or pavement prior to initiating drilling and sampling operations.
3. Decontaminate the split-barrel sampler and sleeves in accordance with the SOP for Equipment Decontamination.
4. Place the decontaminated sampler sleeve(s) into the sampler barrel. Assemble the sampler by aligning both sides of the barrel and then attaching the drive shoe and head to the barrel's bottom and top, respectively.
5. Attach the soil sampler to the drill rod assembly and advance it 18 inches bgs or the total length of the sampler.

6. Retrieve the sampler from the borehole and disassemble it. Remove the bottom 6 inches of the sample from the unlined sampler and transfer it to the appropriate containers. If sample sleeves are used and full recovery is achieved, typically, the middle sleeve shall constitute the soil sample for analytical analysis. The ends of the middle sleeve should be quickly noted for lithological descriptions, the sample prepared for shipment and the remaining soil from the remaining sleeves used to describe the soil for that drive interval. The sleeve used for analytical analysis is dependent on the purpose of the sampling. Consult the PM for direction. If the soil is the litholgically the same throughout the interval, the less disturbed sample should be used for analytical analysis. The number of sleeves to be sent depends upon project analytical requirements. The top sleeve or top portion of the sampler is often material that has fallen back in the borehole and is not characteristic of the sample depth. If inadequate sample recovery is obtained, use material from the bottom sleeve first, followed by whatever material is in other sleeves, or attempt to recollect the sample. Sleeve samples shall also be packaged and handled in accordance with the SOP for Sample Handling.
7. When collecting subsurface soil samples, advance the drill bit and rod assembly to the top of the next desired sampling interval. After removing any excess cuttings from the borehole and tripping the drill bit out of the borehole, attach the empty decontaminated soil sampler to the drill rod assembly and lower it into the borehole.
8. Mark the drill rods in successive 6-inch increments so that the advance of the soil sampler can be easily observed by the environmental engineer/geologist. Advance the split-barrel sampler the required distance (generally 18 inches) with blows from the hammer.
9. Count the number of blows applied for each 6-inch increment of sampler advance into subsurface soils and record this information on the borehole log in accordance with the SOP for Field Documentation and Borehole Logging. Sampler refusal is generally indicated if more than 50 blows are required to advance the sampler 6 inches.
10. If an orientated geotechnical sample is required, mark each of the sample sleeves, if used, with a “T” and a “B,” using a wax crayon or a pen with indelible ink, to indicate stratigraphic “top” and “bottom,” respectively. Log the exposed soil at the ends of each sample sleeve other than the lowest in accordance with the SOP for Borehole Logging.
11. Without disturbing the sample, seal the ends of each sample sleeve with Teflon sheeting and tightly fitting plastic end caps. The end caps may then be held in place with silicone tape.
12. If another soil sample is to be collected at a greater depth in the same borehole, drill to the desired depth, reattach the split-barrel sampler to the drill rod assembly, and follow Steps 5 through 8 above. Be sure to decontaminate the sampler between samples.
13. Label sample sleeves using the sample numbering system described in the Project Work Plan and the sample identification numbers generated for the specific locations. The sample identification number for split-barrel samples shall include the

sample depth, accounting for the appropriate incremental depth based on the location of the sleeve within the split-barrel sampler. Record other required field logbook information as specified in the SOP for Field Documentation.

14. Follow Steps 15 and 16 of Section 6.2.2.

6.3.2 Continuous sampler (Physical characterization only – not for analytical sampling)

1. Don clean, disposable nitrile or latex surgical gloves to prevent cross-contamination and provide personal protection. New gloves will be donned for sample collection at each location, or whenever gloves are torn or otherwise compromised.
2. Using the drilling equipment (e.g., hollow stem augers), advance the soil boring to the depth immediately above the sampling interval.
3. Attach the continuous sampler to the rods or cable and insert into the hollow-stem augers (or casing) and lower it to the bottom of the borehole.
4. Advance the sampler ahead of the augers into the undisturbed sampling interval.
5. Retrieve and split open the sampler.
6. Log the samples in accordance with the SOP for Borehole Logging.

6.4 Field Sampling Using EPA 5035

Collection and storage of soils for VOC analysis using current US EPA methodology has changed since the promulgation of SW846 Method 5035. The EnCore™ Sampler is one of three collection options promulgated from the change in SW846 Method 5035. The other two collections are Acid Preservation and Methanol Preservation. The other two methods are employed only if field constraints are such that samples cannot be shipped and received by a laboratory within 24 to 36 hours of sampling. EPA Method 5035 calls for the preservation of samples if analysis cannot occur within 48 hours. To allow adequate time for the laboratory to preserve the samples if necessary, the laboratory should receive them within 24 to 36 hours of collection. This section describes the proper procedures and methods to be employed in the collection and shipment of soil samples collected under EPA Method 5035.

Innovative Technologies (1-888-411-0757) is at this time the only supplier of the Encore™ sampler. Detailed information from Innovative Technologies about the Encore sampler™ is provided in Attachment C.

6.4.1 Collection of samples for Low Level Analyses (> 1 µg/kg)

Each sample point requires two 5g samplers, one 25g sampler or one 5g sampler for screening and/or high level analysis, one dry weight cup, one T-handle and paper towels. The number of samplers required may be different from these typical numbers based on the QAPP requirements for the project. The Project chemist should be consulted in determining the number of Encore™ samplers required for the project. The procedure is as follows:

1. Remove sampler and cap from package and attach T-handle to sampler body. Make sure that the sampler is locked into place in the T-handle.

2. Quickly push sampler into a freshly exposed surface of soil until the sampler is full. The sampler is full when the o-ring is visible in the hole on the side of the T-handle.
3. Use paper towel to quickly wipe the sampler head so that the cap can be tightly attached.
4. Push cap on with a twisting motion to attach cap.
5. Place sampler into the package.
6. Fill out label and attach to the package, where specified for the label..
7. Repeat procedure for the other two samplers.
8. Collect dry weight sample – fill container. If other samples (non-Encore™) are collected for the same sampling interval, the dry weight sample may be designated and analyzed using the other sample.
9. Store samplers at 4 degrees Celsius.
10. Ship sample containers with plenty of ice to the laboratory. Samples must arrive at the laboratory **within 40 hours** of collection.

6.4.2 Acid Preservation Sampling for Low Level Analyses (> 1 µg/kg)

This procedure should be done in the field only if field constraints prevent shipment to the laboratory such that the laboratory cannot perform the analysis within 48 hours (or samples will not arrive within 24 to 36 hours of collection).

Each sample point requires the following equipment:

- One 40ml VOA vial with acid preservative (for field testing of soil pH).
- Two pre-weighted 40ml VOA vials with acid preservative and stir bar (for lab analysis).
- Two pre-weighted 40 ml VOA vials with water and stir bar (in case samples effervesces).
- One pre-weighted jar that contains methanol or a pre-weighted empty jar accompanied with a pre-weighted vial that contains methanol (for screening sample and/or high level analysis).
- One dry weight cup.
- One 2 oz jar with NaHSO4 acid preservative (in case additional acid is needed due to high soil pH).
- One scoop capable to deliver about one gram of solid sodium bisulfate.
- pH paper.
- Weighing balance that weighs to 0.01 gram (filed balances may not reliably weigh to 0.01 gram).
- Set of balance weights used in daily balance calibration.

- Gloves for working with pre-weighted sample vials.

The field chemistry procedure for testing effervescing capacity of soils is as follows:

1. Place 5 grams of soil into vial that contains acid preservative and no stir bar.
2. Do not cap this vial as it may EXPLODE upon interaction with the soil.
3. Observe the sample for gas evolution (due to carbonates in the soil).
4. If vigorous or sustained gas evolution occurs, then acid preservation is not acceptable to preserve the sample. In this case, the samples need to be collected in the VOA vials with only water and a stir bar. The vials with acid preservative CANNOT be used.
5. If a small amount or no gas evolution occurs, then acid preservation is acceptable to preserve the sample. Keep this testing vial for use in the buffering testing detailed below. In this case, the samples need to be collected in the VOA vials with the acid preservative and a stir bar.

The field chemistry procedure for testing buffering capacity of soils is as follows:

1. If acid preservation is acceptable for sampling soils than the sample vial that was used in the effervescing testing can be used here for testing the buffering capacity of the soil.
2. Cap the vial that contains 5 grams of soil, acid preservative and no stir bar from Step #1 in the effervescing testing.
3. Shake the vial gently to attempt to make a homogenous solution.
4. When done, open the vial and check the pH of the acid solution with the pH paper.
5. If the pH paper reads below 2 then the sampling can be conducted in the two pre-weighted 40 ml VOA vials with the acid preservative and stir bar. Since the pH was below 2, it is not necessary to add additional acid to the vials.
6. If the pH paper reads above 2, then additional acid needs to be added to the sample.
7. Use the jar with the solid sodium bisulfate acid and add another gram of acid to the sample.
8. Cap the vial and shake thoroughly again.
9. When done, open the vial and check the pH of the acid solution with a new piece of pH paper.
10. If the pH paper reads below 2 then the sampling can be conducted in the two pre-weighted 40 ml VOA vials with the acid preservative and stir bar and one extra gram of acid.

11. Make a note of the extra gram of acid needed so the same amount of extra acid can be added to the vials the lab will analyze.
12. If the pH paper reads above 2, then add another gram of acid and repeat this procedure one more time.

The procedure for collection of samples is as follows:

1. Wear gloves during all handling of pre-weighed vials.
2. Quickly collect a 5 gram sample using a cut off plastic syringe or other coring device designed to deliver 5 grams of soil from a freshly exposed surface of soil.
3. Carefully wipe exterior of sample collection device with clean paper towel.
4. Quickly transfer to the appropriate VOA vial, extruding with caution so that the solution does not splash out of the vial.
5. Add more acid if necessary (this is based on the buffering testing discussed on the previous section).
6. Use the paper towel and quickly remove any soil off of the vial threads.
7. Cap vial and weigh the jar to the nearest 0.01 gram.
8. Record exact weight on the sample label.
9. Repeat sampling procedure for the duplicate VOA vial.
10. Collect dry weight sample – fill container.
11. Store samples at 4 degrees Celsius.
12. Ship containers with plenty of ice and per DOT regulations to the laboratory.

6.4.3 Encore™ Sampler Collection For High Level Analyses (> 200 µg/kg)

Each sample point requires the following equipment:

- One 25g sampler or one 5g sampler. (The sampler size used will be dependent on who is doing the sampling and who is doing the laboratory analysis).
- One dry weight cup.
- One T-handle.
- Paper towels.

The procedure for collecting soil samples is as follows:

1. Remove sampler and cap from package and attach T-handle to sampler body. Make sure that the sampler is locked into place in the T-handle.
2. Quickly push sampler into a freshly exposed surface of soil until the sampler is full. The sampler is full when the o-ring is visible in the hole on the side of the T-handle.
3. Use paper towel to quickly wipe the sampler head so that the cap can be tightly attached.
4. Push cap on with a twisting motion to attach cap.
5. Place sampler into the package.
6. Fill out label and attach to the package, where specified for the label.
7. Collect dry weight sample – fill container. If other samples (non-Encore™) are collected for the same sampling interval, the dry weight sample may be designated and analyzed using the other sample.
8. Store samplers at 4 degrees Celsius.
9. Ship sample containers with plenty of ice to the laboratory. Samples must arrive at the laboratory **within 40 hours** of collection.

6.4.4 Methanol Preservation Sampling for High Level Analyses (> 200 µg/kg)

This procedure should be done in the field only if field constraints prevent shipment to the laboratory such that the laboratory cannot perform the analysis within 48 hours (or samples will not arrive within 24 to 36 hours of collection).

Methanol preservation of each sample point requires the following equipment:

- One pre-weighted jar that contains methanol or a pre-weighted empty jar accompanied with a pre-weighted vial that contains methanol.
- One dry weight cup.
- Weighing balance that weighs to 0.01 gram (filed balances may not reliably weigh to 0.01 gram).
- Set of balance weights used in daily balance calibration.
- Gloves for working with pre-weighted sample vials.
- Paper towels.

The procedure for collection of soil samples is as follows:

1. Wear gloves during all handling of pre-weighed vials.
2. Weigh the vial with methanol preservative in it to 0.01 gram. If the weight of the vial with methanol varies by more than 0.01 gram from the original weight recorded on the vial - discard the vial. If the weight is within tolerance it can be used for soil preservation below.

3. Tare the empty jar or the jar that contains the methanol preservative.
4. Quickly collect a 25 gram or 5 gram sample using a cutoff plastic syringe or other coring device designed to deliver 25 gram or 5 gram of soil from a freshly exposed surface of soil. The 25 gram or 5 gram is dependent on who is doing the sampling and who is doing the laboratory analysis.
5. Carefully wipe the exterior of the collection device with clean papa towel.
6. Quickly transfer the soil to an empty soil jar that contains methanol. If extruding into a jar that contains methanol be careful not splash the methanol outside of the vial. Again, the type of jar received is dependent on who is doing the laboratory analysis.
7. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided – using only one vial of methanol preservative per sample jar.
8. Use the paper towel and remove any soil off of the vial treads and cap the jar.
9. Weigh the jar with the soil in it to 0.10 gram and record the weight on the sample label.
10. Collect dry weight sample – fill container.
11. Store samples at 4 degrees Celsius.
12. Ship containers with plenty of ice and per DOT regulation to the laboratory.

6.5 Bulk Soil Sampling

Large volumes of soil are generally not required for environmental investigations. However, soil samples may be collected in bulk with a backhoe from test-pits or trenches to a maximum depth of approximately 15 to 25 feet . A bucket auger may be used to collect bulk soil samples to maximum depths of 250 feet if the soils are unsaturated.

If bulk sampling is required for a given project, the procedure for sample collection will be provided in the project Work Plan. In general, any bulk sampling conducted on a project will follow the procedures discussed under the sections above. Whether samples will be composited into stainless steel bowls, collected under EPA 5035, or into sample sleeves will be determined and described in the project Work Plan.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

In order to assess the accuracy and precision of the field methods and laboratory analytical procedures, quality assurance/quality control (QA/QC) surface and subsurface soil samples are collected during the sampling program according to the project Work Plan. QA/QC samples may be labeled with QA/QC identification numbers or fictitious identification numbers if blind submittal is desired, and are sent to the laboratory with the other samples for analyses. The frequency, types, and locations of QA/QC samples are specified in the project Work Plan. Examples of QA samples are equipment rinsate samples, duplicate samples, matrix spike/matrix spike duplicate samples, performance evaluation samples, and laboratory blind duplicate samples.

7.1 Equipment Rinsate Samples

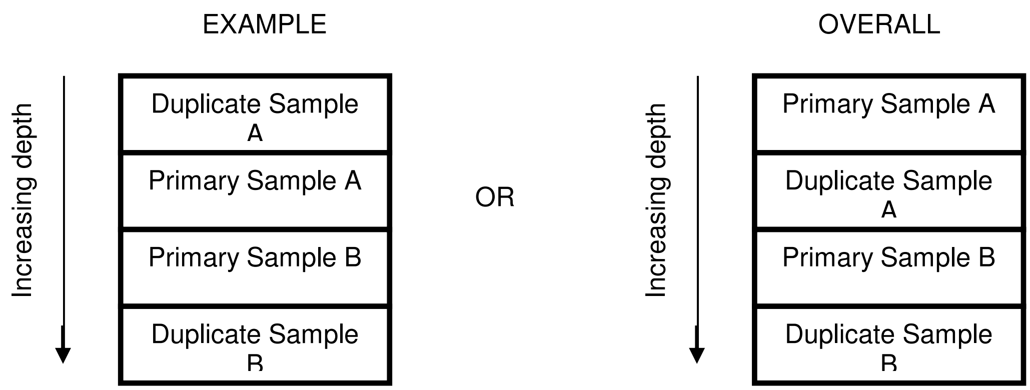
An equipment rinsate sample is intended to check if decontamination procedures have been effective and to assess potential contamination resulting from containers, preservatives, sample handling and laboratory analysis. Procedures for collection are as follows:

1. Rinse the decontaminated sampling apparatus with deionized water. Allow the rinsate to drain from the sampling apparatus directly into the sample bottle.
2. Add any preservatives associated with the soil sample analytical methods to the rinsate sample.
3. Specify (on the COC) the same analytical methods for rinsate samples as is specified for the soil samples.
4. For validation reasons, assign the rinsate sample an identification number and label as rinsate samples, not as blanks.
5. Place the rinsate sample in a chilled cooler and ship it to the laboratory with the other samples.

7.2 Duplicate Samples

Duplicate samples are collected to assess the precision of field and laboratory components of field samples and matrix heterogeneity. Duplicate samples are similar to split samples and should be collected like split samples. Project specifications will determine if the duplicate samples are homogenized. If so, proceed with the instructions for homogenization in Section 6.2.1. Otherwise, the collection of duplicate samples will be collected in the next consecutive sample. For example, if a 18-inch long split barrel contains three 6-inch long full sleeves of soil. The middle sleeve is designated as the primary sample, then the next sleeve, either the top or bottom sleeve must be the duplicate sample.

The collection of duplicate samples is more complex, when more sleeves are needed for analyses. For example, for the same split barrel and three full sleeves of soil, two sleeves are necessary for the primary analyses (i.e. A and B). In this scenario the duplicate is the next sleeve. The middle sleeve can be designated as Primary Sample A, the top sleeve as the duplicate for Primary Sample A and the third sleeve as Primary Sample B. The duplicate for Primary Sample B must be collected from the top sleeve in the next split barrel, which means the sampler must be driven again into the soil from the point where the last sampler stopped. The example and the overall relationship of collection of the primary and duplicate soil samples are illustrated below.



To maximize the information available in assessing total precision, collect duplicate samples from locations suspected of the highest contaminant concentration. Use field measurements (such as HNu data) or visual observations, past sampling results, and historical information to select appropriate locations for duplicate analyses.

The duplicate sample is handled and preserved in the same manner as the primary sample and assigned a sample number, stored in a chilled cooler, and shipped to the laboratory with the other samples. Whenever possible, the sample identification numbers for the characteristic sample and its duplicate are independent such that the receiving laboratory is not able to distinguish which samples are duplicates prior to analysis.

7.3 Matrix Spike/Matrix Spike Duplicate Samples

An extra volume of sample media may be collected during the sampling event for performance of matrix spike (MS)/matrix spike duplicate (MSD) analyses by the laboratory to assess laboratory accuracy, precision, and matrix interference. Following shipment of the samples to the laboratory, the laboratory prepares MS and MSD samples by homogenizing the soil matrix collected in the field and splitting the material into three separate sets of containers. Note that sample aliquots for volatile analysis are not homogenized. The laboratory spikes the split samples with appropriate analytes prior to performing the extraction in order to evaluate the total of the spiked compound and whatever quantity of the compound may be present in the sample. Results of the analyses are compared with the results of the primary sample and the known concentrations of the spike compounds. The percent recovery and relative percent difference are calculated and results are used to evaluate the precision and accuracy of the analytical method for various labeled "extra volume samples for MS/MSD." The sample volumes required for these analyses should be coordinated with the laboratory and are described in the project Work Plan.

7.4 Performance Evaluation Samples

Performance evaluation or pre-spiked soil samples may be used to assess laboratory extraction efficiency and accuracy in constituent identification and quantification. Because these samples are helpful in assessing the potential bias of analytical methods, they are also commonly used to evaluate the accuracy of non-standard methods or mobile laboratory procedures. These samples are generally prepared by an independent laboratory and shipped in pre-sealed containers to the field to be included with the samples sent to the laboratory performing the analysis of site soil samples. As for field blanks, these spiked samples are generally limited to organic constituents. The analytes of interest and corresponding analyte concentrations for the spike samples must be specified in the request to the independent laboratory providing the samples in accordance with the project Work Plan. These samples are assigned an identification number, stored in a chilled cooler, and shipped blind to the laboratory with the other samples.

7.5 Laboratory Blind Duplicate Samples

If appropriate, or required by program Quality Assurance, laboratory blind duplicate samples may also be used to assess laboratory accuracy in constituent identification and quantification. Laboratory blind duplicate samples consist of two or more representative sample volumes from one heterogeneous soil sample obtained from one sampling location. Equal volumes of representative aliquots from the mixture are submitted to two or more laboratories for analysis. The results of each laboratory are compared as a check on the laboratory accuracy. Because two samples are analyzed, environmental variability and precision (from one location to another) are included in this assessment.

The laboratory blind duplicate sample volume collected by the sampling team is preserved, packaged and submitted for analysis in the same manner as the other characteristic samples in accordance with the project Work Plan.

7.6 Other Sample Types

Ambient or background samples are used to assess the range of concentrations of potential contaminants and naturally occurring inorganic compounds in the vicinity of the site which are not the result of site activities. These samples are collected from areas not believed impacted by historical site operations (i.e., away from source areas and upwind).

The ambient or background samples are collected at the locations and depths specified in the project Work Plan. If the locations are not specified, a nearby park or other area void of industrial activity, for example, may be suitable for collection of ambient samples. The soil type should be as close as possible to the onsite characteristic samples. If appropriate, information can be obtained from various state and local agencies (e.g. USDA Natural Resources Conservation Service) that could aid in selection of ambient soil sampling locations. Ambient soil samples should be collected following the same procedure as that used for the onsite soil samples.

8.0 REFERENCES

U.S. Environmental Protection Agency, A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, December 1987.

U.S. Environmental Protection Agency, Compendium of ERT Soil Sampling and Surface Geophysics Procedures, EPA/540/
P-91/006, Interim Final, January 1991.

U.S. Environmental Protection Agency, Description and Sampling of Contaminated Soils - A Field Pocket Guide, EPA/625/P-12-91/902, November 1991.

American Society for Testing Materials, Annual Book of ASTM Standards, Section 4, Volume 4.08, Practice for Soil Investigation and Sampling by Auger Borings, ASTM D 1452-80 (1990), 1992.

American Society for Testing Materials, Annual Book of ASTM Standards, Section 4, Volume 4.08, Standard Method for Penetration Test and Split-Barrel Sampling of Soils, ASTM D 1586-84, 1992.

American Society for Testing Materials, Annual Book of ASTM Standards, Section 4, Volume 4.08, Standard Practice for Thin-walled Tube Sampling of Soils, ASTM D 1587-88, 1992.

American Society for Testing Materials, Annual Book of ASTM Standards, Section 4, Volume 4.08, Practice for Ring-Lined Barrel Sampling of Soils, ASTM D 3550-84 (1991), 1992.

American Society for Testing Materials, Annual Book of ASTM Standards, Section 4, Volume 4.08, Standard Practice for Preserving and Transporting Soil Samples, ASTM D 4220-89, 1992.

En Novative Technologies, Inc., SW846 Method 5035 Field Sampling Guide, February 1998.

9.0 ATTACHMENTS

None

SOP-12
Field Classification and Description of Soils and Rock

Yerington Mine Site
Standard Operating Procedure

Revision 0
Revision Date: June 6, 2006

SOP-12
FIELD CLASSIFICATION AND DESCRIPTION OF SOILS AND ROCK

TABLE OF CONTENTS

1.0 OBJECTIVES

This objective of this Standard Operating Procedure (SOP) is to establish a consistent method for field staff to follow when completing the description of soil and rock samples obtained from field sampling efforts and entry into borehole logs. Consistency with description is important because during many projects multiple employees may be involved at different times. Hence, being able to compare between logs that were created by different geologists is essential for creating subsurface interpretations.

2.0 SCOPE AND APPLICABILITY

This procedure will be used during all field activities when bore hole subsurface drilling, surface soil or rock sampling, reconnaissance geological mapping is occurring. These activities should be documented as described herein, and following the SOP for Field Notes and Documentation (SOP-03).

3.0 RESPONSIBILITIES

The *Project Manager (PM)* shall ensure that the soil or rock classification and description procedures used in the field conform to the guidelines in this SOP. The PM shall ensure that all field personnel providing descriptions are properly trained to conduct this task and are providing descriptions under the oversight of a Senior Geologist registered in the state in which the logging is occurring. If the state does not have requirements for registration, then the Senior Geologist should meet the standards for a professional geologist under that states law or be registered in another state.

The *Field Supervisor* is responsible for reviewing lithologic logs for accuracy and completeness prior to releasing them to the project manager for review.

The *Field Geologist* is responsible for following the soil classification and description procedures in this SOP, and for accurately and completely representing the lithology encountered in the field

4.0 DEFINITIONS

ASTM. American Society for Testing Materials.

Feldspathoids. Alkali (potassium) or basic (plagioclase) feldspar.

IUSG. International Union of Geological Sciences

USCS. Unified Soil Classification System.

5.0 MATERIALS REQUIRED

The materials required for completing the procedures outlined in this SOP, at a minimum, include the following:

- Hand lens
- Field notebook and borehole log forms
- Protractor

- Pencils
- Pocket knife
- Dilute hydrochloric acid in small dispenser
- Field charts of grain size examples (e.g., American Geological Institute [AGI] data sheets)
- Squirt bottle with water
- Compass with altimeter

6.0 METHODS

The following sections provide guidance for how proper field visual descriptions of soils and rock samples should be conducted. These methods may not be applicable to every soil or rock sample found, but should provide enough guidance to allow accurate and defensible descriptions by a variety of field geologists.

6.1 DESCRIPTION OF SOILS

The following section provides a description of the procedures that should be used when describing soils.

6.1.1 General Considerations

The most popular soil classification method that is based on grain size and other properties, is the Unified Soil Classification System (USCS). This system was initially developed by A. Casagrande in 1948 and was then called the Airfield Classification System. It was adopted with minor modifications by the U.S. Bureau of Reclamation and the U.S. Corps of Engineers in 1952. In 1969, the American Society for Testing and Materials (ASTM) adopted the system. This system is designated currently by ASTM as D-2488-90 and will be used as a guideline for classifying and describing lithology. It requires certain information (e.g. liquid limit, plastic limit moisture content and plasticity index) about the soil which can only be obtained in a laboratory.

The USCS is based on grain size and response to physical manipulation at various water contents. This system is often used for classifying soils encountered in boreholes, test pits, and surface sampling. The following properties form the basis of USCS soil classification:

- Percentage of gravel, sand, and fines;
- Shape of the grain size distribution curve; and
- Plasticity and compressibility characteristics.

Four soil fractions are recognized. They are cobbles, gravel, sand, and fines (silt or clay). The soils are divided as coarse grained soils, fine grained soils, and highly organic soils. The coarse grained soils contain 50 percent of grains coarser than a number 200 sieve (approximately 0.08 mm). Fine grained soils contain more than 50 percent of material smaller than the number 200 sieve. Organic soils contain particles of leaves, roots, peat, etc.

6.1.2 Soil Description Procedures

The following will be used as a guideline for logging lithology from subsurface activities (i.e. borehole drilling, trenching, etc.).

The USCS recognizes 15 soil groups and uses names and letter symbols to distinguish between these groups. The coarse grained soils are subdivided into gravels (G) and sands (S). Both the gravel and sand groups are divided into four secondary groups. Fine grained soils are subdivided into silts (M) and clays (C).

Soils are also classified according to their plasticity and grading. Plastic soils are able to change shape under the influence of applied stress and to retain the shape once the stress is removed. Soils are referred to either low (L) or high (H) plasticity. The grading of a soil sample refers to the particle size distribution of the sample. A well graded (W) sand or gravel has a wide range of particle sizes and substantial amounts of particles sized between the coarsest and finest grains. A poorly graded (P) sand or gravel consists predominately of one size or has a wide range of sizes with some intermediate sizes missing.

Soils which have characteristics of two groups are given boundary classifications using the names that most nearly describe the soil. The two groups are separated by a slash. The same is true when a soil could be well or poorly graded. Again the two groups are separated by a slash.

Soil description should be concise and stress major constituents and characteristics for fine-grained, organic, or coarse-grained soils. Tables 1 and 2 are checklists for descriptions of fine-grained, organic soils, and coarse-grained soils, respectively. Field descriptions should include as a minimum:

> Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.
>
> Particle Size Distribution. An estimate of the percentage and grain-size range of each of the soil's subordinate constituents with emphasis on clay-particle constituents. This description may also include a description of angularity. This parameter is critical for assessing hydrogeology of the site and should be carefully and fully documented.
>
> Gradation or Plasticity. For granular soil (sands or gravels) that should be described as well-graded, poorly graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soil (silts or clays) should be described as non-plastic, low plastic, medium plastic, or highly plastic.
>
> Dry Strength. Dry strength describes the crushing characteristics of a dry soil crumb about ¼ inch (5 mm) in diameter. If a crumb of dry soil is not available, after removing particles larger than No. 40 sieve size, mold at least three balls of soil about ¼ inch (5 mm) in diameter to the consistency of putty, adding water if necessary. Allow the balls to dry completely by oven, sun, or air drying, and then test their strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
>
> Dilatancy. Dilatancy describes the soils reaction to shaking. After removing particles larger than No. 40 sieve size, prepare a ball of moist soil about ½ inch (15 mm) in diameter. Add

enough water, if necessary, to make the soil soft but not sticky. Place the ball in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the ball which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the ball stiffens, and finally cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Toughness. Toughness is the consistency of the soil near the plastic limit. After removing particles larger than the No. 40 sieve size, mold a ball of soil about ½ inch (15 mm) in diameter to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The specimen is then rolled out by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. The thread is folded and rerolled repeatedly. During this manipulation, the moisture content is gradually reduced and the specimen stiffens, finally loses it plasticity, and crumbles when the plastic limit is reached.

Color. The basic color of the soil (refer to Munsell soil color charts).

Odor. Odor is described from a warm, moist sample. The odor should only be described if it is organic or unusual. An organic odor will have distinctive decaying vegetation smell. Unusual odors, petroleum product, chemical, and the like should be described.

Soil Texture and Structure. Description of particle size distribution, arrangement of particles into aggregates, and their structure. This description includes joints, fissures, slicked sides, bedding, veins, root holes, debris, organic content, and residual or relict structure, as well as other characteristics that may influence the movement or retention of water or contaminants.

Moisture Content. The amount of soil moisture described as dry, moist, or wet/saturated.

Relative Density or Consistency. An estimate of density of a fine-grained soil or consistency of a cohesive soil, usually based on standard penetration tests.

Cementation. An estimate of cementation of a coarse-grained soil.

Relative Permeability. An estimate of the permeability based on visual examination of materials (e.g., high permeability for course sand and gravel verses low permeability for silty clay). The estimate should address presence and condition of fractures (open, iron-stand, calcite-filled, open but claylined, etc.), as well as fracture density and orientation;

Local Geologic Name. Any specific local name or generic name (i.e., alluvium, loess).

Group Symbol. USCS of symbols.

The soil logs should also include a complete description of any tests run in the borehole; placement and construction details of piezometers, wells, and other monitoring equipment; abandonment records; geophysical logging techniques used; and notes on readings obtained by air monitoring instruments.

The following tables outline the criteria used for determining the descriptive classification of soils based on simple field tests.

Criteria for Describing Plasticity

Descriptive item	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any moisture content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times close to the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Criteria for Describing Dry Strength

Descriptive item	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces and crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very high	The dry specimen cannot be broken between the thumb and a hard surface.

Criteria for Describing Dilatancy

Descriptive item	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear, or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Toughness

Descriptive item	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The lump and thread have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Moisture

Descriptive item	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet/saturated	Visible free water, usually soil is below water table.

Structure (for description of soils only)

Descriptive item	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
Laminated	Alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Criteria for Describing Consistency

Descriptive item	Criteria
Very soft	Thumb penetrates soil more than 1 inch
Soft	Thumb penetrates about 1 inch
Firm	Thumb indentation up to ¼ inch
Hard	No indentation with thumb, readily indented with thumbnail
Very Hard	Not indented with thumbnail

Criteria for Describing Cementation

Descriptive item	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

6.2 DESCRIPTION OF ROCK

The following section provides a description of the procedures that should be used when describing rock samples.

6.2.1 General Considerations

Rock identification is based on minerals and textures. Drilling in rock will be slow and core recovery may consist of pulverized chips. The proper drilling technique is necessary for adequate recovery and accurate rock identification.

6.2.2 Rock Description Procedures

Rocks can be categorized into three types: sedimentary, igneous, and metamorphic. Descriptions for these three types of rocks are different. The following procedures are organized following the three categories.

***Sedimentary Rock Classification*.**

Sedimentary rocks result from two processes (and combinations thereof):

- Consolidation of loose sediments that have accumulated in layers, forming *clastic rocks*.
- Precipitation from solution to form a *chemical rock*. Included in this category are rocks directly or indirectly formed by biological processes.

The following text summarizes how to characterize these two types of sedimentary rock.

Clastic Rocks. Clastic rocks have been classified different ways. They may be classified according to the size of particles, sorting, and distribution of particles, or chemical content of silica, feldspar, and calcite.

Grain Size. In the most commonly used classification system, the size of the particles determines the general rock name. For example, sand-sized particles for sandstones; pebbles form conglomerates, and so on. The rack names are shown in the table below along with their component particle sizes. The divisions in the classification are based upon the Modified Wentworth scale used to measure grain size.

Grain Size Scale (Modified Wentworth Scale)

Diameter (in)	Particle	Sediment	Rock
< 0.0002	Clay	Mud	Claystone, mudstone, shale
0.0002 to 0.002	Silt		Siltstone
0.002 to 0.08	Sand	Sand	Sandstone
0.08 to 2.5	Pebble	Gravel	Conglomerate (rounded)
2.5 to 11.8	Cobble		
> 11.8	Boulder		Breccia (angular)

Conglomerates and breccias have adjectives such as *clast-supported and matrix supported*. *Clast-supported* means that he clasts are sorted well enough so that the large clasts touch, and *matrix-supported* is not.

A well-sorted sandstone is called an arenite. A poorly sorted sandstone with a matrix of silt and clay is called a wacke. A sandstone with more than 25% feldspar is an arkose. And, if lithic fragments or iron and magnesium minerals and feldspar are present along with quartz sand and silt, the rock is called a graywacke.

Sorting. Sedimentary rock names are further characterized by the sorting the particles have undergone. The distribution of grain sizes reflects the type of transport a sediment has experienced and the depositional environment. A well-sorted (or poorly graded) sediment has two or three sizes present. A poorly sorted (or well-graded) sediment has a wide range of grain sizes present.

Cementation. Cementing substances have usually been referred to by adjectives such as calcareous, dolomitic, and siliceous; however, these terms might also imply accessory detrital materials, so that the unambiguous terms calcite-cemented, dolomite-cemented, and quartz-cemented are recommended.

Chemical Rocks. Chemical rocks have been classified according to chemical composition, depositional texture, and depositional environment.

Common chemical rocks are limestone, dolomite, evaporites (gypsum, anhydrite, halite, etc.) phosphate rocks (apatite), manganese nodules, ironstones (limonite, siderite, and chlorite silicates), coal, pyrite, chert, and diatomite, and some cherts have a biogenic component to their formation.

Igneous Rock Classification.

Classification of igneous rocks is based upon the mineral content of the rock. Minerals upon which the classification is based are feldspar, quartz (or feldspathoids), and mafic minerals such as biotite, hornblende, pyroxene, and olivine. Of these minerals, identifying feldspar is the key to classification.

The International Union of Geological Sciences (IUGS), Sub commission on the Systematics of Igneous Rocks attempted to create a universal classification of igneous rocks. The committee's recommendations for plutonic and volcanic rocks are shown in the following two tables, respectively. A rock is classified by determining it composition relative to the percentage of alkali feldspar, plagioclase, and quartz (or feldspathoid).

Modal Classification of Plutonic Igneous Rocks

Modal Values	**Classification**
Q > 60	Not igneous
Q = 20-60, P <10	Alkali feldspar granite
Q = 20-60, P = 10-65	Granite
Q = 20-60, P = 65-90	Granodiorite
Q = 20-60, P >90	Tonalite
Q = 5-20, P <10	Alkali feldspar quartz syenite
Q = 5-20, P = 10-35	Quartz syenite
Q = 5-20, P = 35-65	Quartz monzonite
Q = 5-20, P = 65-90	Quartz monzodiorite (An < 50), Quartz monzogabbro (An > 50), Quartz anorthosite (M < 10)
Q = 5-20, P >90	Quartz diorite (An < 50), Quartz gabbro (An > 50), Quartz anorthosite (M < 10)
Q = 0-5, P <10	Alkali feldspar syentie
Q = 0-5, P = 10-35	Syenite
Q = 0-5, P = 35-65	Monzonite
Q = 0-5, P = 65-90	Monzodiorite (An < 50), Monzogabbro (An > 50), Anorthosite (M < 10)
Q = 0-5, P >90	Diorite (An < 50), Gabbro (An > 50), Anorthosite (M < 10)
F = 0-10, P <10	Foid-bearing alkali feldspar quartz syenite
F = 0-10, P = 10-35	Foid-bearing syenite
F = 0-10, P = 35-65	Foid-bearing monzonite
F = 0-10, P = 65-90	Foid-bearing monzodiorite (An < 50), Foid-bearing monzogabbro (An > 50)
F = 0-10, P >90	Foid-bearing diorite (An < 50), Foid-bearing gabbro (An > 50)
F = 10-60, P <10	Foid syenite
F = 10-60, P = 10-50	Foid monzosyenite
F = 10-60, P = 50-90	Foid monzodiorite (An < 50) Foid monzogabbro (An > 50)
F = 10-60, P >90	Foid diorite (An < 50), Foid gabbro (An > 50)
F > 60	Foidolites

Q = quartz/(quartz = alkali feldspar = plagioclase)
F = feldspathoids/(feldspathoids = alkali feldspar)
P = feldspathoids/(feldspathoids = plagioclase feldspar)
M = color index
An = % anorthite inplagioclase

Modal Classification of Volcanic Igneous Rocks

Modal Values	Classification
Q > 60	Not igneous
Q = 20-60, P <10	Alkali feldspar rhyolite
Q = 20-60, P = 10-65	Rhyolite
Q = 20-60, P = 65-90	Dacite
Q = 20-60, P >90	Dacite
Q = 5-20, P <10	Alkali feldspar quartz trachyte
Q = 5-20, P = 10-35	Quartz trachyte
Q = 5-20, P = 35-65	Quartz latite
Q = 5-20, P = 65-90	In all six fields, the names andesite and basalt are applied; basalt is used if SiO_2 < 52wt % after H_2O and CO_2 are deleted and the analysis recalculated to sum 100%
Q = 5-20, P >90	
Q = 0-5, P = 65-90	
Q = 0-5, P >90	
F = 0-10, P = 65-90	
F = 0-10, P >90	
Q = 0-5, P <10	Alkali feldspar trachyte
Q = 0-5, P = 10-35	Trachyte
Q = 0-5, P = 35-65	Latite
F = 0-10, P <10	Foid-bearing alkali feldspar quartz trachyte
F = 0-10, P = 10-35	Foid-bearing trachyte
F = 0-10, P = 35-65	Foid-bearing latite
F = 10-60, P <10	Phonolite
F = 10-60, P = 10-50	Tephritic phonolite
F = 10-60, P = 50-90	Phonolitic tephrite
F = 10-60, P > 90	Tephrite (olivine < 10%) Basanite (olivine > 10%)
F > 60	Foidite

Q = quartz
P = feldspathoids/(feldspathoids = plagioclase feldspar)
F = feldspathoids/(feldspathoids = alkali feldspar)

***Metamorphic Rock Classification*.**

In this binomial system for naming metamorphic rocks, the main rock name is based on the texture of the rock, and the principal or more significant minerals are added as modifying nouns, as in biotite-quartz schist or andalusite-cordierite hornfels. The names are meant to be applied on a descriptive basis; a schistose rock, for example, should not be called a hornfels just because it is found in a contact aureole.

Textures.

- Schistose – grains platy or elongate and oriented parallel or subparallel. *Foliated* (lepidoblasitc) of fabric is planar, *lineated* (nematoblastic) if linear.
- Granobalstic – grains approximately equidimensional; platy and linear grains oriented randomly or so subordinate that foliation is not developed.
- Hornfelsic – grains irregular and interincluded but generally microscopic; recognized in field by unusual toughness, ring to hammer blow, and hackly fracture at all angles. Under hand lens, freshly broken surfaces show a sugary coating that will not rub off (formed by rending of interlocking grains).
- Semischistose (gneissic) – platy or linear grains subparallel but so subordinate or so unevenly distributed that rock has only a crude folliation; especially common in metamorphosed granular rocks, such as sandstones and igneous rocks.
- Cataclastic – clastic textures resulting from breaking and grinding with little if any recrystallization; characterized by angular, lensoid, or rounded fragments (porphyroclasts) in a fine-grained and commonly streaked or layered
- Groundmass. *Mortar structure* applies to nonorientated arrangements, and *phacoidal*, *flaser*, and *augen structure* apply to lenticular arrangements.

Rock Names.

Schistose Rocks.

- Schist – grains can be seen without using a microscope.
- Phyllite – all (or almost all) grains of groundmass are microscopic, but cleavage have sheen caused by reflections from platy or linear minerals; commonly corrugated.
- Slate – grains are microscopic; very cleavable; surface dull; tougher than shale and cleavage commonly oblique to bedding.
- Phyllonite – appearance like phyllite but formed by cataclasis (see mylonite) and recrystallization commonly of coarser-grained rocks, as indicated by relict rock slices, slip folds, and prophyroclasts.

Granoblastic Rocks.

- Granulite or Granofels – granoblastic rocks, irrespective of mineral composition; because granulite can connote special compositions and conditions or origin, granofels may be preferred.
- Quartzite, marble, and amphibolite – compositional names that generally connote granoblastic texture; exceptions should be modified for clarity, as schistose quartzite or plagioclase hornblende schist.
- Tactite (skarn) – heterogeneous calc-sillicate granulites and related metasomatic rocks of typically uneven grain.

Hornfelsic Rocks.

- All called hornfels, or, if relict features are clear, hornfelsic may be used with the original rock name (as hornfelsic andesite)

Semi-schistose (Gneissic) Rocks.

- Semi-schist – fine-grained (typically less than 1.4 mm) so that individual platy or lineate grains are indistinct; relict features often common.
- Gneiss – generally coarser than ½ mm with small aggregates of platy or lineate grains forming separate lenses, bladed, or streaks in otherwise granoblastic rock. Platy or lineate structures may be distributed evenly through the rock or may be concentrated locally so that some layers or lenses are granoblastic or schistose (banded gneiss).

Cataclastic Rocks. Where original nature of rock is still apparent, rock name can be modified by suitable adjectives (as cataclastic granite, flaser gabbro, phacoidal rhyollite).

- Mylonite – crushing so thorough that rock is largely aphanitic and commonly dark-colored; may be layered and crudely folliated but not schistose like phyllonite; porphyroclasts commonly rounded or lenticular.
- Ultrmylonite, pseudotachyylyte – aphanitic to nearly vitreous-appearing dark rock commonly injected as dikes into adjoining rocks.

Relict and Special Textures and Structures. If textures of low-grade metamorphic rocks are dominantly relict, original rock names may be modified (as massive metabasalt, semischistose met-andesite). If hydrothermal alteration has produces prominent new minerals, names such as chloritized diorite and sercitized granite can be used.

- Strongly metasomatized rocks with coarse or unusual textures may require special names such as gneissen, quartz-schorl rock, and corundum-mica rock.
- Magmatite – a composite rock composed of igneous or igneous-appearing and/or metamorphic materials that are generally distinguishable megascopically.

7.0 REFERENCES

American Society for Testing and Materials (ASTM), 1990, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), ASTM Standard D-2488-90.

Dunn, I.S., Anderson, L.R. and Kiefer, F.W., 1980, Fundamentals for Geotechnical Analysis, John-Wiley, New York.

Compton, Robert R., 1985, Geology In The Field, John Wiley & Sons, New York.

Osiecki, P. and Dirth, L., 1996, RG Exam Study Guide.

International Union of Geological Sciences (IUGS) Sub commission on the Systematics of Igneous Rocks, 1973, "Plutonic rocks, classification and nomenclature," *Geotimes*, 18, no. 10, pg. 26-30.

U.S. Bureau of Reclamation, Geotechnical Branch, 1986, Visual Classification of Soils, Unified Soil Classification System, Denver, Colorado.

8.0 ATTACHMENTS

Attachment A - Checklist for the Description of Fine-Grained Soils

Attachment B - Checklist for the Description of Coarse-Grained Soils

ATTACHMENTS

Attachment A

Checklist for Description of Fine-grained and Organic Soils

Items of descriptive data	Typical information desired for silt and clay
Group name	SILT, LEAN CLAY, ETC., include cobbles and boulders in typical name when applicable.
Size distribution	Approximate percent of fines, sand, and gravel of fraction less than 3 inch in size; must add to 100 percent
Plasticity of fines	Nonplastic; low; medium; high
Dry strength	None; low; medium; high; very high
Dilatancy	None; slow; rapid
Toughness near plastic limit	Low; medium; high
Moisture condition	Dry; moist; wet
Color	Munsell color chart; if possible, note mottling or banding
Odor	Only mention of organic or related to contaminants
Structure	Stratified; laminated; fissured; slickensided; blocky; lensed; homogeneous
Consistency	Very soft; soft; firm; hard; very hard
Relative Permeability	Low; medium; high; fractures, open, iron-stand, calcite-filled, open but claylined
Local Geologic Name	If applicable
Group symbol	CL, CH, ML, MH, OL/OH, or appropriate borderline symbol when applicable; should be compatible with typical name used above

Attachment B

Checklist for Description of Coarse-grained Soils

Items of descriptive data	Typical information desired for sand and gravel
Group name	WELL-GRADED GRAVEL WITH SAND, ETC., will include cobbles and boulders in typical name when applicable.
Gradation	Describe range of particle sizes, such as fine to medium sand or fine to coarse gravel, or the predominant size or sizes as coarse, medium. Fine sand or coarse or fine gravel.
Size distribution	Approximate percent of gravel, sand, and fines in the fraction finer than 3 inch; must add to 100 percent.
Plasticity of fines	Nonplastic; low; medium; high
Particle shape	Flat, elongated, or flat and elongated (if applicable)
Particle angularity	Angular; subangular; subrounded; rounded
Moisture condition	Dry; moist; wet
Color	Munsell color chart
Odor	Only mention of organic or related to contaminants
Structure	Stratified; lensed; homogeneous
Cementation	Weak; moderate; strong
Relative Permeability	Low; medium; high; fractures, open, iron-stained, calcite-filled, open but claylined
Local Geologic Name	If applicable
Group symbol	GP, GW, SP, SW, GM, GC, SM, SC, or the appropriate symbol when applicable; should be compatible with typical name used above
Mineralogy	Rock hardness for gravel and coarse sand. Note presence of mica flakes, shaly particles, or organic matter.